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AEROSPACE GROUND EQUIPMENT MECHANIC

(AFSC 42355)

Volume 5

Bomb Lifts, Diesels, Generators, and Dispatcher Vehicle Operations

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Preface

VOLUME 5 of this Career Development Course (42153) contains information pertaining to munitions handling equipment, diesel engines, generator sets, and dispatcher vehicle operations. Chapter 1 is devoted to the MJ–1A/1B bomb lift truck. Diesel engines are discussed in Chapter 2, and Chapter 3 will cover the Hollingsworth generator set. The last chapter of this volume will cover Dispatcher Vehicle Operations.

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Contents

Chapter		Page
	Preface	*iii*
1	Bomb Lift	1
2	Diesel Engines	7
3	Generator Set	23
4	Dispatcher Vehicle Operations	31
	Answers for Exercises	45

Bomb Lift

SINCE WE HAVE discussed hydraulic support equipment in a previous volume, it is only fitting that a section be devoted to the bomb lift truck. The "jammers," as they are often called, have had a place in AGE (aerospace ground equipment) for several years now, and yet many repairmen are not familiar with their operation and repair. On the other hand, it is likely that one day you may find yourself assigned to a bomb lift shop and totally responsible for maintaining them.

1-1. MJ-1A/1B Bomb Lift Truck

An understanding of system operation and maintenance techniques on this unit will better prepare you to meet your qualifications and assume your responsibilities as a mechanic.

800. Specify operation fundamentals of the MJ-1A/B bomb lift truck.

The MJ-1A/B bomb lift truck will be discussed in three functional sections: the engine, hydrostatic drive system, and main hydraulic system.

The bomb lift truck is mounted on a low-slung, heavy-duty frame supported by four small, high-capacity wheels. The vehicle has a rear wheel drive, powered by a gasoline or diesel engine, mounted on the extreme rear of the frame. The two rear wheels are steerable from a conventional steering wheel located in the midsection of the unit. All power is supplied by a 27.5 hp gasoline engine for the MJ-1A or a 25.2 hp diesel engine for the MJ-1B.

Engine. The purpose of the engine is to provide a source of power for mobility of the unit and power hydraulic pumps for system operation. The engine used in the MJ-1A is a Wisconsin Motor Corporation Model VH4D, four-cylinder, air-cooled gasoline engine. The engine used in MJ-1B is a Hatz 25.2, two-cylinder, air-cooled diesel engine.

Hydrostatic Drive System Operation. Power from the engine is transmitted to drive the rear wheels by a hydrostatic drive system. This consists of a fluid coupling between the engine and differential. A variable displacement hydraulic pump is connected to the engine and a fixed displacement hydraulic motor is connected to the differential. The amount of oil delivered from the pump to the motor determines how fast the truck moves. By changing the stroke of the pistons (displacement), the flow rate of the pump can be varied by changing the engine speed with the throttle control or with the accelerator pedal. When the accelerator pedal is pushed full forward, the stroke of the pistons within the pump is at the maximum and the truck will perform as if it were in third gear. When the accelerator pedal is in the up position, there is no stroke of the pistons within the pump, and the truck will not move regardless of engine speed. Forward or reverse direction is obtained by actuation of the directional control lever to the right of the instrument panel. Either motion is then accomplished by pushing down on the accelerator pedal in the normal manner. By a combination of engine speed and displacement control, the truck may be driven at speeds which vary from a few feet per hour to 10-15 miles per hour, in forward or reverse. Generally, the engine speed should be adjusted to 2400 RPM with the throttle control and truck speed controlled with the accelerator pedal. The hydrostatic motor is equipped with a manually operated rotary by-pass valve which is operated from the rear of the unit. The valve has two positions, one for drive and one for tow. The valve positions are identified by stencils on the rear of the bumper. The truck will not operate (move) under its own power if the rotary by-pass valve is in the tow position.

Hydraulic System. The hydraulic system is used to supply fluid under pressure to operate components of the bomb lift. The principle components of the hydraulic system are hydraulic tank, piston pump, control valves, lift arm cylinders, cradle cylinders, hand pump, steering system, airbleed valve, counterbalance valves, and hydraulic manifolds.

Hydraulic tank. The hydraulic tank is located along the right side of the bomb lift. This tank or reservoir stores the hydraulic fluid to be used in the system. The tank is never filled to the top, so thermal expansion of the fluid might occur without causing an overflow of fluid.

Piston pump. The function of the piston pump is to supply fluid under pressure for the operation of the lift cylinders and the cradle cylinders. Fluid is directed from the pump through the pressure manifold. The manifold distributes the fluid to the lift arm control valve and to the cradle control valve assembly. With the proper use of these controls, the operator can correctly position the load to the aircraft. The piston pump is belt-driven by the engine from the drive end of the hydrostatic pump. The piston pump has rated output of 10 gpm at 1000 psi. Overpressurization of the hydraulic system is prevented by a pressure relief valve,

which is built into the pump's discharge section. It is factory-set and should not be reset by the AGE mechanic. If the piston pump fails to operate, the use of the hand pump will be required to pressurize the system.

Hand pump. The hand pump is located on the right side of the bomb lift, just below the instrument panel. It provides pressure in the hydraulic system in the event of piston pump or engine failure. Pressure output varies from 0 to 1500 psi. This manually operated pump has a volume output of two cubic inches per cycle.

Air bleed valve. The airbleed valve is used to bleed any trapped air from the hydraulic system. This air is bled off through the return manifold back to the hydraulic tank. Fluid from the piston pump is likely to contain small amounts of air. This entrapped air could cause an unsafe operation of the hydraulic system. To remove this air the fluid must flow through the airbleed valve, which is located at a higher point than the pump. The valve is spring-loaded to the open position, allowing the entrapped air to flow through the valve.

Steering system. The power steering system contains three basic components: the steering pump, the steering sector, and the heat exchanger. The pump, a two-gear positive displacement type, has a rated output of 3 gpm at 600 psi. A pressure regulator incorporated in the housing of the pump prevents an overpressurization of the power steering system. Fluid from the gear pump is sent to the steering sector. The steering sector is connected to the rear wheels through the use of mechanical linkage. When the steering wheel is turned, the steering sector uses the pressurized fluid from the pump to aid in the turning of the rear wheels. The heat exchanger cools the hydraulic fluid. It is an automotive, radiator-type oil cooler.

Counterbalance valves. The function of the counterbalance valves, sometimes called overcenter valves, is to prevent collapsing of the cantilever lifting arms in the event of hydraulic pressure failure. The valves require a specific value of pressure to operate; if adequate pressure is not available, the load cannot be lowered. Thus, the valves prevent inadvertent collapse of the cantilever lift arms.

Lift arm cylinders. The two lift arm cylinders actuate the cantilever lift arms and are rated to lift a 3,000-pound weight to maximum height in 9 seconds. The lift arm cylinders actually do the work by converting hydraulic pressure into mechanical motion to lift or lower the lift arms.

Exercises (800):

1. What is the difference between the MJ–1A and the MJ–1B bomb lift truck?

2. What is the purpose of the rotary by-pass valve?

3. What component controls the forward and reverse directions of the bomb lift truck?

4. The flow rate of the pump can be varied by which component(s)?

5. Which component supplies fluid under pressure for the operation of the lift and cradle cylinders?

6. What component prevents overpressurization of the hydraulic system and where is it located?

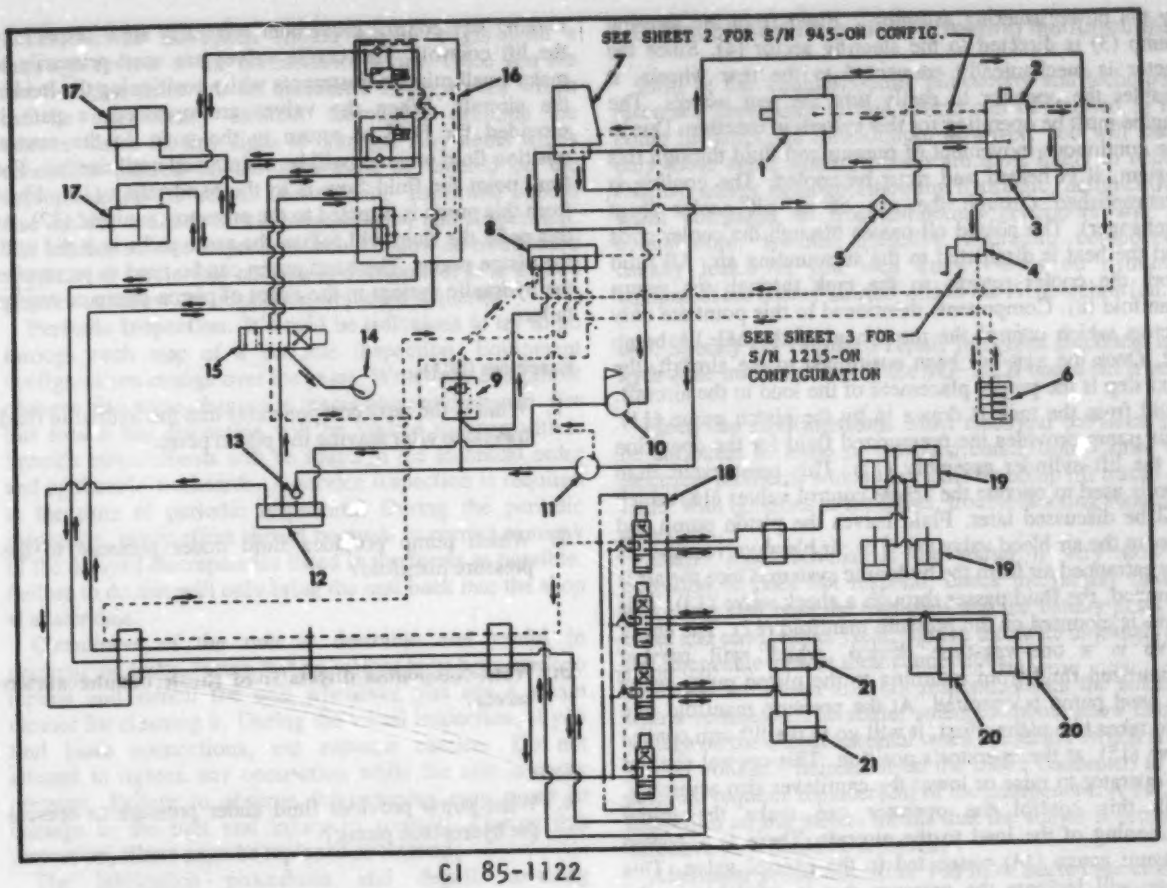
7. State the function of the counterbalance valves?

801. Give operational details of the hydraulic system flow in the MJ–1A/B bomb lift truck.

A suggested method to use when tracing fluid flow is to start at any operating component, such as a lift cylinder, and then trace back through the piping to the fluid reservoir. Always remember that hydraulically operated devices must have two lines: one line for supply and one line to return displaced fluid.

Hydraulic System. Now that you have an understanding of what each component does, let's bring them all together to see their relationship to each other by using the hydraulic system diagram (fig. 1-1).

First of all is the hydraulic tank (7). The tank is the storage container for the hydraulic fluid. The filter (5) for the hydraulic system is located inside the tank. There is one other filter (5a) for the hydrostatic drive system. Each filter removes foreign particles from the fluid before the fluid reaches the respective system. The tank has a useable capacity of approximately 6 gallons. Never fill the tank to the top, but if the level of fluid is low, more fluid can be added through the filler cap. The filler cap is located on the tank and it provides the only breather (vent) for the hydraulic system. This vent prevents the tank from being pressurized. Fluid is directed to the piston pump (11), hand pump (10), steering pump (3), and to the hydrostatic pump (2) through the pump manifold, which is located on the tank. We will take each of these pumps and follow the fluid flow through the system, one at a time. As the fluid leaves the pump manifold, it flows to the hydrostatic drive system. The hydrostatic pump (2) supplies the fluid necessary to operate the hydrostatic motor (1), which enables the unit to move in either the forward or reverse direction. The direction will depend on the position of the directional control lever. Now that we have a means to move the bomb lift, we must control this movement. This is accomplished



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1. Hydrostatic Motor
2. Hydrostatic Pump
3. Steering Pump
4. Steering Sector
5. Filter
6. Heat Exchanger
7. Hydraulic Tank
8. Return Manifold
9. Air Bleed Valve
10. Hand Pump
11. Piston Pump
12. Pressure Manifold
13. Check Valve
14. Pressure Gage
15. Control Valve
16. Counterbalance Valve Assembly
17. Lift Cylinder Assembly
18. Control Valve Assembly
19. Tilt Cylinder Assembly
20. Lateral Cylinder Assembly
21. Longitudinal Cylinder Assembly
22. Relief Valve

Figure 1-1. Hydraulic system diagram.

by the power steering assembly. Fluid from the steering pump (3) is directed to the steering sector (4). Since the sector is mechanically connected to the rear wheels, it enables the operator to easily turn the rear wheels. The engine must be operating for this system to function. Due to the continuous movement of pressurized fluid through this system, it is heated and must be cooled. The cooling is accomplished through the use of an oil cooler (heat exchanger). The heated oil passes through the cooler coils and the heat is dissipated to the surrounding air. All fluid from the cooler returns to the tank through the return manifold (8). Components mentioned to this point are only factors which control the movement of the MJ-1A bomb lift. Once the unit has been positioned to the aircraft, the next step is the proper placement of the load to the aircraft. Fluid from the tank is drawn in by the piston pump (11). This pump provides the pressurized fluid for the operation of the lift cylinder assembly (17). This pressurized fluid also is used to operate the cradle control valves (18) which will be discussed later. Fluid leaves the piston pump and goes to the air bleed valve (9). The air bleed valve removes any entrapped air from the hydraulic system. Once the air is removed, the fluid passes through a check valve (13). This valve is mounted on the pressure manifold (12). The check valve is a one-way-type device, which will prevent pressurized fluid from returning to the piston pump when the hand pump is operated. At the pressure manifold, the fluid takes two paths. First, it will go to the lift arm control valve (15), at the operator's position. This control enables the operator to raise or lower the cantilever arm assembly. With this control the operator can make the initial positioning of the load to the aircraft. There is a system pressure gauge (14) connected to the control valve. This gauge will indicate the pressure that is available in the hydraulic system. With this valve being operated, fluid is directed to either the lift cylinder assemblies (17), through the counterbalance manifold, and the counterbalance valves (16). The manifold will direct the fluid to either the cylinder assembly or to the counterbalance valves, depending on the position of the lift arm control valve. The fluid will flow either back through the counterbalance valve to the counterbalance manifold or just back to the manifold, depending on the position of the control valve. From the control valve, all the fluid is directed back to the return manifold and to the tank. If the control valve is in the neutral position, the fluid pressure is maintained until needed. Returning to the pressure manifold, there is one other path for fluid to leave this compartment. The pressurized fluid will flow to the cradle control valve assembly (18), through two manifolds on the lift arm assembly. This control assembly fluid pressure is provided at four locations: tilt control valve, lateral control valve, longitudinal control valve, and to a second lift arm control valve. The operation of these valves will direct fluid pressure to their corresponding cylinder assemblies. The tilt will direct fluid to the tilt cylinder assembly (19), the lateral valve to the lateral cylinder assembly (20), the longitudinal valve to the longitudinal cylinder assembly (21), and the lift valve to the lift cylinder assembly (17). Due to the size of these valves, only small amounts of fluid will flow, thus making any control movement relatively slow (especially the lift control). The cradle valves are used primarily to make small minor adjustments while positioning the load to the aircraft. When the valves are operated, a path is provided for fluid to return to the tank. In the neutral position fluid pressure will be maintained until needed. The final point for fluid flow is to the hand pump (10). Fluid from this pump is directed to the pressure manifold (12). At this point the fluid will follow the same paths as it did with the piston pump. The hand pump can be used to pressurize the hydraulic system in the event of piston pump or engine failure.

Exercises (801):

1. What is the next component(s) that the hydraulic fluid travels to after leaving the piston pump?

2. Which pump provides fluid under pressure to the pressure manifold?

3. What component directs fluid to the counterbalance valves?

4. What pump provides fluid under pressure to operate the hydrostatic motor?

5. What is the purpose of the check valves mounted on the pressure manifold?

1-2. Inspections

By this time you should have acquired a thorough understanding of the inspection requirements for any type of AGE. The inspections of the MJ-1A bomb lift are performed using the same procedures as those used for any other AGE equipment.

802. State specific information pertaining to inspections of the MJ-1A/B bomb lift truck.

Service Inspections. The service inspection of the bomb lift should always be performed in accordance with the inspection workcards and the unit technical order. To re-emphasize, anytime there is a discrepancy between the workcards and the TO, the information and requirements contained in the workcards should prevail. You must always use the TO and workcards together to insure that a thorough inspection has been completed.

The service inspection should always begin with a thorough review of the maintenance forms. Once you are satisfied that there are no uncleared discrepancies which can be immediately cleared, thoroughly examine the exterior frame for any signs of damage. Any items which cannot be cleared on the spot must be entered on the appropriate AFTO form. The exterior inspection should also include a check of the tires, wheels, and suspension. The interior service inspection should follow an established sequence to insure that nothing is overlooked. It is a good practice to follow the inspection workcard sequence.

Periodic Inspection. It would be ridiculous to try to go through each step of a periodic inspection. Equipment configurations change over the years. With these equipment changes also come changes in inspection requirements. For this reason our discussion will be limited to generalities. Specific requirements will be found in the technical order and applicable workcards. A service inspection is required at the time of periodic inspection. During the periodic inspection, every effort should be made to correct as many of the delayed discrepancies listed in the forms as possible. Failure to do this will only bring the unit back into the shop at a later date.

Cleanliness of the unit is desirable and useful in determining leaks. Insure that provisions have been made to repaint and stencil the unit whenever you use a steam cleaner for cleaning it. During the visual inspection, if you find loose connections, use extreme caution. Do not attempt to tighten any connection while the unit is under pressure. Failure to observe this warning may result in damage to the unit and injury to yourself. During this inspection, filters must be replaced or cleaned.

The lubrication procedures and details covering lubrication points, types of lubricants to be used, and method of application found in applicable technical data, should always be followed. Sound logic and maintenance practices should be followed to provide hand oil can lubrication to known metal chafing or movement points that may not be identified in applicable technical data. The complete unit is lubricated during every periodic inspection. Remember that if you find a conflict between the unit technical data and the workcard, the workcard will always take precedence.

Exercises (802):

1. What is the first item to be checked when performing a service inspection of the MJ-1A/B bomb lift?

2. Under what type of inspection is a complete lubrication done?

3. When a workcard and TO are in conflict, which one must you follow?

1-3. Troubleshooting and Correcting Malfunctions

Most of the troubleshooting philosophy and techniques discussed previously in this course can be applied to the bomb lift truck. In this section, however, you will study only those areas where troubles are most likely to occur. One advantage in troubleshooting hydraulic malfunctions, when compared to troubleshooting generators and air compressors, is that defective hydraulic components usually leak. As you well know, leaks on hydraulic equipment are enemy number one to the AGE technician.

803. Specify the required repair for given electrical and hydraulic malfunctions of the MJ-1A/B bomb lift truck.

Electrical Malfunctions. Most electrical problems can be attributed to loose or corroded connections. Since the electrical problems which may exist on bomb lift trucks are either with ignitions or the lights, troubleshooting should be easy.

Starter malfunctions. If the starter is very slow in operation or does not respond, check the battery first to make sure that both the terminals and the battery posts are clean and serviceable. Next, tighten the cable terminals and the other cable ends at their connections.

Should the starter still not respond, check the solenoid with a voltmeter. The starter solenoid should show battery voltage on the output terminal when the starter switch is on. A "no voltage" indication on the meter connected to the solenoid requires replacement of the component. A voltage indication on the meters means that the starter is probably defective and should be replaced.

Alternator problems. After you have started the engine, check the ammeter on the instrument panel to insure that the alternator is charging. If there is no charge indicated on the meter, shut the engine off and proceed with further checks. Normal reading should show a slight charge. The alternator is located within the flywheel housing of the engine. The alternator is gear driven by the flywheel ring gear on the opposite side from the starter. This unit uses a flywheel alternator system. A series of coils (stator) is mounted to the engine gear cover. Permanent magnets in the flywheel rotate around these stationary coils to produce electricity when the engine is running. The electrical system on the MJ-1A is different from the electrical system on the MJ-1B bomb lift in that they have different engines. Always refer to applicable technical data when troubleshooting either system.

Hydraulic Malfunctions. Failure of a hydraulic component due to a broken hydraulic line will be immediately apparent because of the presence of a large pool of hydraulic fluid under the lift truck. But for malfunctions other than leaks or broken lines, consider the following causes for the indicated malfunction:

(1) If the cantilever lift arms (boom) are lowering unevenly, the overcenter valves may be improperly set and need adjustment. To adjust the overcenter valves, screw down on the valve adjustment screw to increase required pressure or screw out on the adjustment screw to decrease required pressure. An adjustment in either direction may correct the condition. Be sure to set both valves the same.

(2) But failure of the bomb lift to raise the load during operation can be caused by engine operating speed too slow. This situation is easily corrected by pulling the throttle control out for proper RPM setting. Another cause of this malfunction could be caused by a hydraulic leak, and this will be obviously apparent.

Exercises (803):

1. What causes most electrical failures?

2. What component can give you a visual indication that the alternator is charging?

3. What type alternator does the MJ-1A bomb lift use?

4. What is the most probable cause if the bomb is lowering unevenly?

5. What could cause the boom lift not to raise during operation?

Diesel Engines

THE DIESEL ENGINE is said to be the world's most efficient engine. It delivers more power per pound of fuel than any other engine. Until recently, diesels were used primarily in power plants and large trucks. Diesel engines of today are built in sizes ranging from a few horsepower to 10,000 horsepower and, because of improved engineering, have virtually unlimited use possibilities.

2-1. Engine Comparison

Mechanically, there is little difference between the gasoline and diesel engine. Both have cylinders, pistons, connecting rods, valves, a crankshaft and other components with which you are familiar. The difference lies in the construction of these components. Diesel engine parts are heavier and stronger than those of a gasoline engine. The most important difference is the method employed to cause ignition of fuel in the cylinders. Because of the similarities in construction and operation, frequent comparisons will be made between the diesel and gasoline engine. We will begin by examining the components that are similar.

804. Specify the effects the construction of components have on the operation of a diesel engine and state what size rings you should install in a given case.

Cylinder Block. The exterior of the diesel engine cylinder block differs so little from that of a gasoline engine cylinder block that observers are often unable to tell them apart. One important difference is in the casting of the water jacket. Many diesel engine cylinder blocks are cast with open water jackets extending into the cylinder bore. To prevent coolant from entering the combustion chamber or lubrication system, the water passages are sealed by cylinder liners.

Cylinder Liners. Two types of cylinder liners are used on diesel engines, the wet type and the dry type. The type of liners used in the engines on which you are working depends on the type of block cast.

Wet-type liners. Wet-type liners are used on engines with the water jacket extending into the cylinder bore. The liners are so named because the coolant comes in contact with the outer surface of the liner. Coolant is contained in the water jacket by two seals on the liner. Fit the bottom seal, an O-ring made of neoprene, into a groove on the bottom of the cylinder liner as shown in figure 2-1. Take care when you install the O-ring to insure that it slides rather than rolls when you install the liner. An improperly installed O-ring could allow coolant to enter the crankcase. To prevent water from entering the combustion chamber, use a copper compression gasket to seal the top of the liner. Placed under the flange of the cylinder liner, the gasket is compressed by the head, thereby creating a water-tight seal.

Dry-type liners. Dry-type liners are used on engines having a closed cylinder water jacket. Dry liners, when installed, make contact with the entire length of the cylinder wall, with the exception of the two-stroke engine. Cylinder liners in a two-stroke engine have holes or ports around the center to permit air for combustion and the expulsion of exhaust gases. There are no ports in the liners of a four-stroke engine. Because there are fewer parts, the dry-type liner is easier to install and to maintain.

Some smaller diesel engines do not use cylinder liners. When the cylinders of an engine on which no liners are installed are worn beyond tech order specification, the cylinder must be rebored. After the cylinder is rebored, you must install oversize pistons and rings. When cylinder liners become worn, they are removed and replaced with cylinder liners of the same size. Pistons and rings then remain standard size through the life of the engine.

Pistons and Rings. The pistons in a diesel engine must withstand not only high pressures but also the resulting changes in temperature and heat expansion. Careful design and construction insure that each piston meets those requirements.

A common material used to make pistons is cast iron. Cast iron pistons have a coefficient of heat expansion similar to that of the cylinder liner. The similarity allows a closer fit of cylinder to liner without danger of seizure or binding. Heavy-duty engines which operate at high speeds most often use forged aluminum pistons. The forged aluminum pistons are stronger and lighter than cast iron pistons.

When you compare the pistons of a gasoline engine and a diesel engine, you will find that the diesel piston has a thicker head and usually longer skirts. The thicker head provides better heat dissipation. Piston shake is decreased by increasing the length of the piston skirt.

To seal the cylinder, pistons are normally fitted with three compression rings. An oil-control ring is also mounted on the piston to insure even distribution of oil on the piston and liner, to aid in cooling, and to remove any excess oil.

As you compared the gasoline and diesel engine, you should have found that some components have been omitted here. These components, such as piston pins, connecting

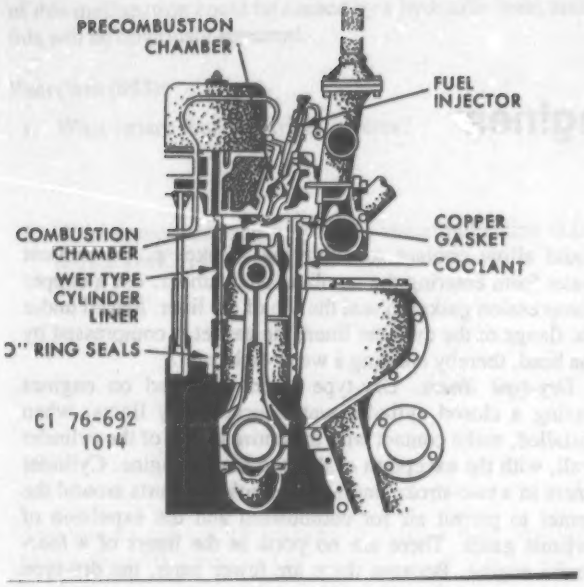


Figure 2-1. Cutaway diesel engine.

rods, and crankshafts, have such minimal differences as to preclude mentioning them in this text.

Exercises (804):

1. Explain the difference between wet- and dry-type cylinder liners.

2. What effect do short skirts have on piston operation?

3. How does piston construction affect heat dissipation?

4. After installing new cylinder liners in a diesel engine, what size rings should you install?

2-2. Cylinder Head Assembly

The cylinder head assembly contains most of the components that control engine operation. Two of the components located in the cylinder head are injection nozzles and valves. The cylinder head also incorporates the combustion chambers and passages for air, exhaust, and coolant.

805. Contrast diesel and gasoline engine valve keepers and state the function of the turbulence chamber.

Valve Mechanism. The valve mechanism encompasses all parts which control the admission of the air charge and the discharge of exhaust gases and, in some engines, the injection of fuel. Valve mechanisms on diesel engines differ considerably, depending on the type, speeds, and size of the engine employed. With the exception of fuel injector operation, diesel valve mechanisms are similar to those of an overhead valve gasoline engine.

Valves. Poppet valves, operated in replaceable cast iron or bronze valve guides, are used on most diesel engines. Valve seat inserts of hardened steel alloy are used for exhaust valves. Intake valve inserts are placed in some high-speed engines. The valves are closed by spring action, as in the gasoline engine. Two or three valve springs are sometimes used on each valve. Multiple valve springs control valve flutter (surging or bouncing), especially at high speeds. The springs are attached to the valve stems by locks or keepers similar to those you have noticed on gasoline engines. Some large diesel engines, however, use nuts screwed onto the valve stem to hold the spring retainer in place.

Combustion Chamber. The design of the combustion chamber is closely associated with the design of the injection nozzle, cylinder head, piston, and finally, with the operation of the engine itself. Combustion chambers are classified into four types: open, pre-combustion, turbulence, and air cell. All but the open chamber are auxiliary chambers used in conjunction with the regular combustion chamber. Regardless of the type used, they are designed to bring sufficient air into contact with the fuel. This provides complete combustion at a constant rate. Since all of the chambers serve the same purpose, we will look at one, the turbulence chamber (fig. 2-2) and examine its effect on engine operation.

Turbulence Chamber. As the piston reaches top dead center, there is very little clearance between the piston and head. This forces about 80 percent of the compressed air into the turbulence chamber. The air forced into the chamber circulates at a high velocity. Fuel is injected into the chamber when air velocity is at its highest, insuring that fuel and the air are thoroughly mixed. With the injection of fuel, combustion takes place. The combustion process is completed within the chamber. The expanding gases are forced through a restricted passage into the small space above the top of the piston, forcing the piston down.

Exercises (805):

1. Explain the difference between the type of valve keepers used on gasoline engines and those used on large diesel engines.

2. How does the turbulence chamber work in conjunction with the cylinder during the combustion process?

2-3. Air Induction System

All internal combustion engines must have sufficient air to operate efficiently. Most engines rely on atmospheric pressure to force air into the cylinders during the intake stroke. The amount of air entering a cylinder depends on the difference between the pressure within the cylinder and the atmospheric pressure. By forcing more air into a cylinder than this difference of pressure can supply, more fuel can be consumed and more power will result. To obtain the increase in air volume, a blower, supercharger, or a turbocharger is installed in the air induction system.

866. Contrast three different air induction systems and state how each operates.

Blower. In the case of a two-stroke, there is a shorter time available for the movement of air into the cylinder on the intake stroke than in the four-stroke-cycle engine. As a result, the two-stroke engine does not naturally take in enough fresh air to completely scavenge or displace the exhaust gases in the cylinder from the previous stroke. This forms a charge deficient in oxygen and results in low power output. To overcome this inherent handicap, an outside source called the blower is used to force a large quantity of low pressure air into the cylinder and increase the scavenging efficiency of the engine.

A common blower (fig. 2-3) consists of an oblong housing with flat end plates; inside are two accurately machined rotors (also called impellers) which rotate in opposite direction. These impellers, mounted on two parallel shafts, have extending parts called lobes. One of the impellers is driven from the engine crankshaft through a train of gears or a silent chain. A pair of spur gears, or timing gears, drives the second impeller. These gears synchronize the rotation of the impellers, that is, give them their correct relative position at all times, and thus prevent them from touching each other. All clearances within the blower are small to prevent any appreciable air leakage from the discharge side to the intake side. The entering air is trapped in the space enclosed by the curved side on the impellers and the side and end covers of the housing. As the impeller rotates further, the space containing the trapped air is opened to the air receiver or manifold. Resistance to the airflow between the receiver and the blower compresses the air. The pressure output of a blower is relatively low, 4 to 7 psi (pounds per square inch). As a result, the blower must put out a large volume of air to compensate for the short time available for the intake stroke. The short intake stroke is caused by intake and exhaust overlap. Overlap is necessary to insure that there is sufficient clean air for the next combustion event.

Supercharger. In order to increase the air pressure in four-stroke-cycle engines, the air charge is not sucked into the cylinder, as it is called, is not admitted due to natural aspiration by the receding piston, but is pushed in by a higher pressure created by a separate air pump or blower. When a supercharger is applied to a four-stroke-cycle engine, the main change required in the engine design is a change in timing of the intake and exhaust valves. The intake valve opening time is advanced and the exhaust valve closing is retarded. The two valves are designed to stay open simultaneously for about 80° to 160°, the selection depending upon the normal engine speed. This simultaneous opening is called overlapping. Tests have shown that an overlap of 40° to 50° increases the power output of an engine by about 5 percent. The total power gain due to supercharging varies from 20 to 50 percent, depending upon the supercharging pressure. It should be noted that supercharging increases the maximum of firing pressure and the maximum temperatures. On the other hand, the fuel consumption usually decreases with supercharging, due to an increase of turbulence and, hence, better mixing of the fuel with the air charge.

Turbocharger. A turbocharger uses normally wasted exhaust energy to increase the amount of air taken into an engine. A greater quantity of fuel may be efficiently used, and the result is an increase in horsepower.

The turbocharger consists of three basic parts: an exhaust gas turbine sometimes called the hot wheel; an impeller or compressor, referred to as the cold wheel; and the housing which supports the parts and directs the flow of exhaust gas and intake air. Exhaust gases passing through the turbine cause it and the compressor impeller to rotate. Air is therefore pumped into the engine and a greater amount is available than would be supplied by normal atmospheric pressure. Hence, more fuel can be burned efficiently, and engine power can be increased. Refer to figure 2-4.

Exhaust gases enter the turbine housing and are directed through vanes of the nozzle toward the turbine blades. The exhaust gases provide the driving force to turn the turbine and are then expelled from the turbine housing and the impeller. Air is compressed as it passes through the impeller and is then directed to the inlet manifold of the diesel engine.

The rotating assembly, consisting of the impeller, the turbine, and their common shaft, is the heart of the turbocharger. These parts are designed and built to operate at extremely high speeds; 50,000 revolutions per minute is often encountered in normal operation. At such high speeds, balance is of utmost importance. A very slight unbalance shows up at high speeds and can be detected by excessive vibration.

Lubricating oil is sealed within the unit by three types of seals depending on the size of the unit. A labyrinth of screw-type seals is used on the large turbocharger. Piston-ring-type oil seals are used with small turbochargers.

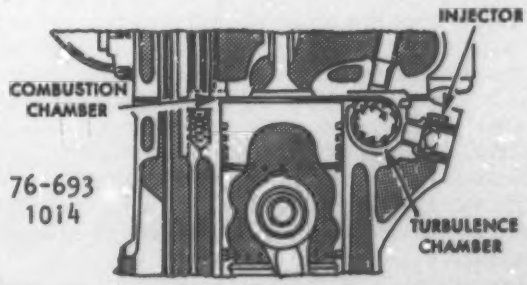
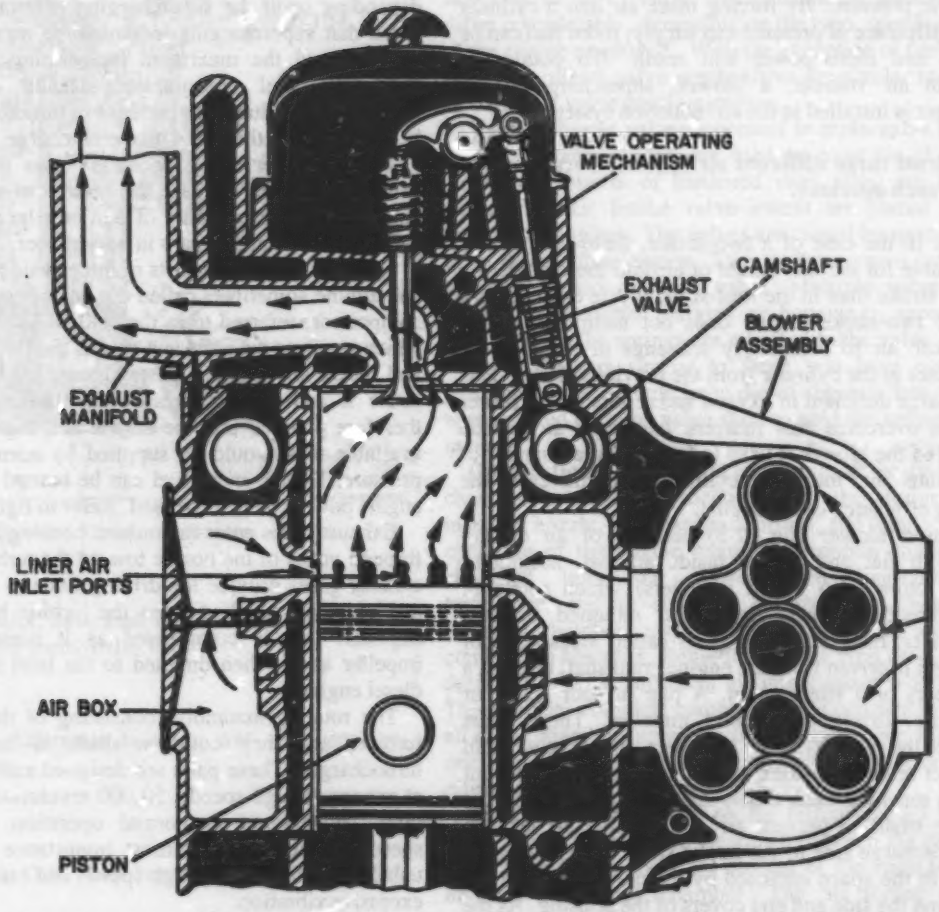


Figure 2-2. Turbulance chamber.



AIR INTAKE EXHAUST SYSTEM (SERIES 71)

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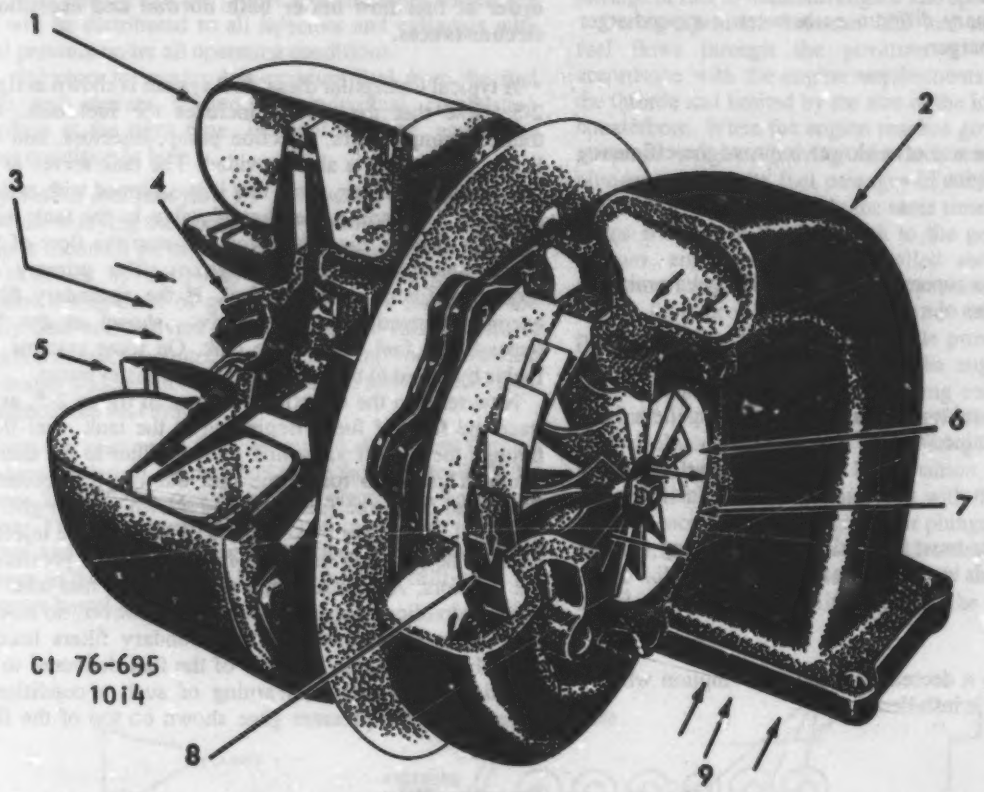
Figure 2-3. Air intake system.



TURBOCHARGER (Cutaway View)

1. Compressor Cover
2. Turbine Housing
3. Air Inlet Opening
4. Impeller
5. Compressor Extension
6. Turbine Wheel
7. Exhaust Outlet
8. Nozzle
9. Exhaust Inlet Opening

Figure 2–4. Turbo charger.

To keep the lubricating oil in the unit and the hot exhaust gases out, air pressure is bled from the compressor housing to balance the normal oil pressure at the impeller seal and the exhaust pressure at the turbine seal.

Exercises (806):

1. List the primary differences between a supercharger and a turbocharger.

2. How does the use of a blower improve the efficiency of a diesel engine?

3. Explain how a supercharger effects the fuel/air mixture in the cylinders of a diesel engine.

4. How is the relative position of the impellers in a blower maintained?

5. What changes must be made in valve timing when a supercharger is installed on a diesel engine?

6. Why is there a decrease in fuel consumption when a supercharger is installed?

7. What is of primary importance in the operation of a turbocharger and why is this feature important?

2-4. Fuel System

The diesel fuel system differs from the gasoline system in several respects. In a gasoline engine, the fuel and air are mixed before they are drawn into the cylinders, and a carburetor meters the mixture to the engine. In a diesel engine, the fuel and air do not mix until both are in the cylinders, and no carburetor is needed. Instead, the air is brought into the cylinders and compressed, after which the fuel is injected. Also, no spark plug is needed because ignition occurs because of the heat of compression. This explains why diesel engines are sometimes called compression-ignition engines. Injectors in the cylinder head spray the fuel at high pressure into the combustion chambers. The fuel, of course, is diesel oil rather than gasoline.

As a mechanic, you will be responsible for maintaining the fuel system on diesel engines. This involves servicing, adjusting, repairing, and timing certain units in the system. Our aim in this section is to supply the information you need to accomplish these tasks. We will start by reviewing the operation of a typical fuel system.

807. List the components in a typical fuel system in the order of fuel flow under both normal and exceptional circumstances.

A typical Caterpillar diesel fuel system is shown in figure 2-5. Note that the system includes the fuel tank, fuel transfer pump, filters, injection pump, injectors, and fuel lines. A governor is also provided. The tank serves as the fuel storage reservoir. Note that it is equipped with an inlet strainer. Also notice the shutoff valve in the tank outlet line. By closing this valve, you can stop the flow of fuel during maintenance on the system. The primary and secondary filters clean the fuel. If the secondary filters become clogged, the relief valve, shown at the left, bypasses the fuel back to the tank. On some systems, the fuel is bypassed to the inlet side of the transfer pump.

Now refer to the directional arrows in figure 2-5, as we trace the flow of fuel. Beginning at the tank, fuel flows through the shutoff valve and primary filter to the transfer pump. This pump forces the fuel through the secondary filters and on to the fuel manifold shown at the right. At this point, the fuel is picked up by plungers in the injection pump. The plungers force the fuel under high pressure to the injectors. Any excess fuel returns to the fuel tank. On some hydraulically operated injectors, however, no leakage fuel return is required. If the secondary filters become partially clogged, the pressure of the fuel delivered to the injection pump drops. Warning of such a condition is indicated by the pressure gage shown on top of the filter housing.

Exercises (807):

1. Through which component is fuel bypassed when the secondary filters are clogged?

2. List the components of a typical fuel system in order of fuel flow.

808. Identify the types of fuel systems to which given components belong; state the principle of each system and specify structural and operational details of each.

Pressure-Time (PT) Fuel System. The Cummins diesel engine uses an exclusive fuel system known as the PT-type fuel system. The abbreviation PT stands for pressure time. The operation of this system is based on the principle that the volume of liquid flow is proportionate to the fuel pressure, the time allowed to flow, and the size of the passage through which the liquid flows. To apply this principle to the PT systems, it is necessary to provide:

a. A fuel pump to draw fuel from the supply tank and deliver it to individual injectors for each cylinder.

b. A means of controlling the pressure of the fuel being delivered by the fuel pump to the injectors so that the individual cylinders will receive the right amount of fuel for the power requirements of the engine.

c. Fuel passages of the proper size and types so that the fuel will be distributed to all injectors and cylinders with equal pressure under all operating conditions.

d. Injectors to receive low-pressure fuel from the fuel pump and deliver it into the individual combustion chambers at the right time, in equal quantity, and in the proper condition to burn.

Operation and fuel flow PT fuel pump. Refer to figure 2-6 while studying the operation of the fuel pump. The gear pump is mounted on the rear of the injector pump housing and is driven by the pump main shaft. The gear pump contains a single set of gears which draws fuel from the supply tank and delivers it throughout the fuel system. A pulsation damper mounted to the gear pump contains a steel diaphragm which absorbs pulsations and smooths fuel flow throughout the fuel system.

From the gear pump (transfer pump), fuel flows through passages drilled in the injector pump housing to the filter screen. The filter screen is held in place by a cover and spring. The fuel enters the screen through a hole in the bottom and is forced through the screen to another drilled passage in the housing that leads to the inlet drilling in the governor barrel.

The governor maintains sufficient fuel for idling with the throttle control in the idle position and it cuts off fuel to the injectors above maximum rated rpm. The governor is actuated by a system of springs and weights. The idle springs in the governor positions the governor plunger in its barrel so that the idle fuel port is open enough to permit passage of fuel to maintain engine idle speed.

During operation between idle and maximum speeds, fuel flows through the governor to the injectors in accordance with the engine requirements as controlled by the throttle and limited by the size of the idle spring plunger counterbore. When the engine reaches governed speed, the governor weights, moving outward, move the governor plunger to close the fuel passages in the barrel and cut off fuel flow to the injectors. At the same time, another passage opens and dumps the fuel back to the gear pump. In this manner, engine speed is controlled and limited by the governor, regardless of the throttle position.

The fuel then leaves the governor and flows through passages to the throttle. The throttle provides a means for the operator manually to control the engine speed above idle, as required by varying operating conditions of speed and load. Rotation of the throttle shaft controls the amount of fuel allowed to pass the shaft and go to the injectors. When the throttle is in the idle position, the idle passage around the throttle shaft is indexed with the idle passage in the governor barrel by the governor plunger uncovering this passage, and fuel flows past the throttle shaft. To operate above idle speed, fuel flows through the main governor barrel port to the throttling hole in the shaft. When the

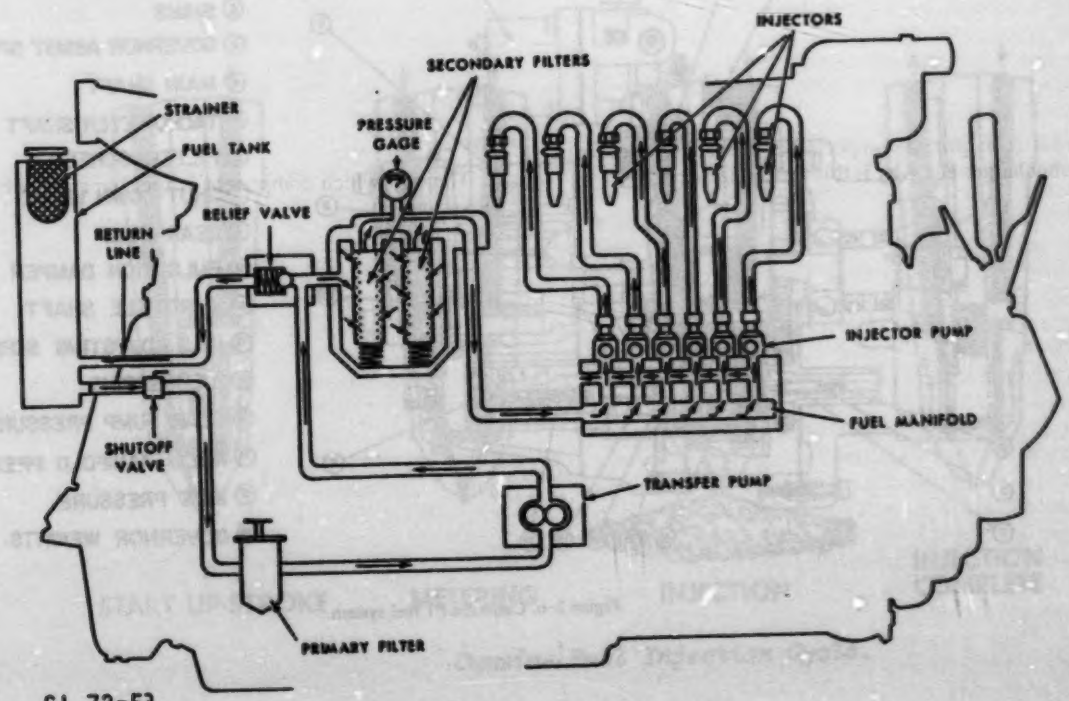
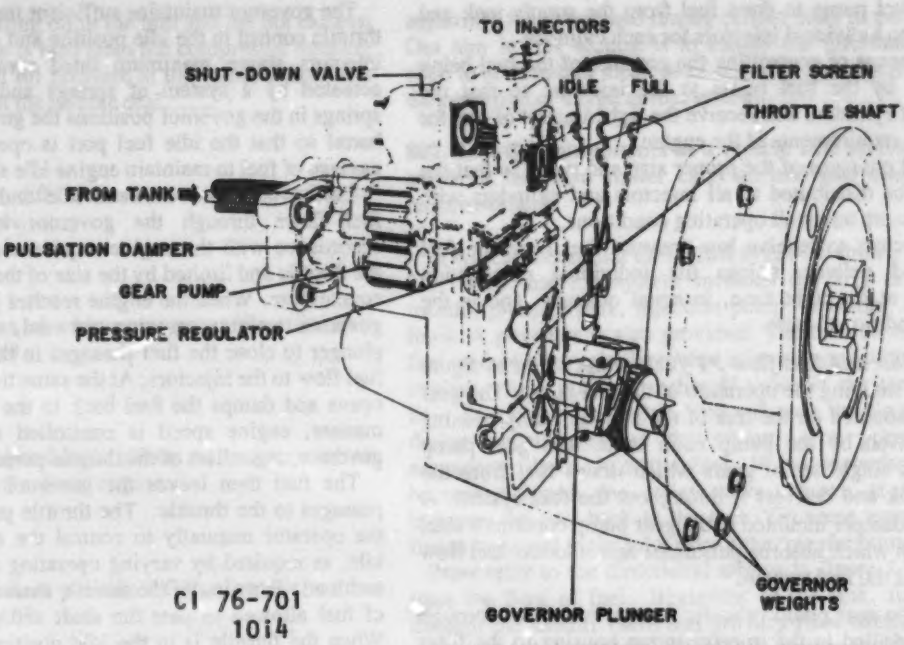
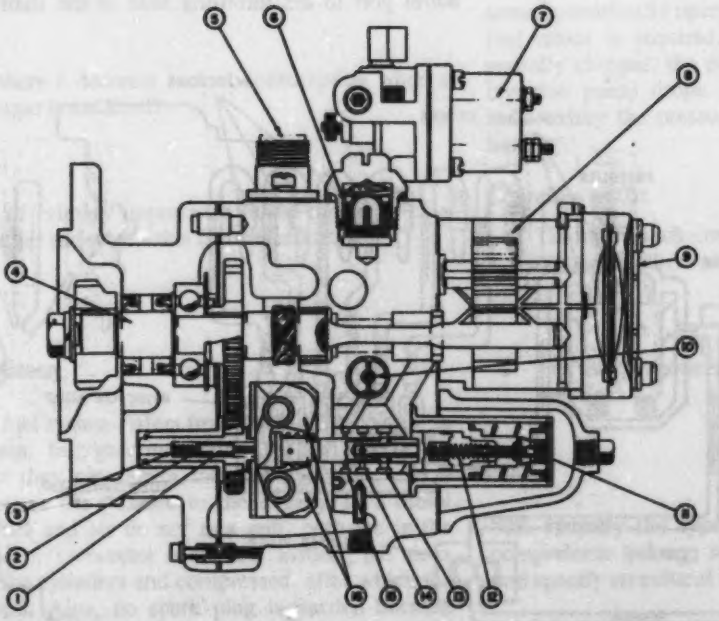


Figure 2-5. Diesel fuel system.





① GOVERNOR ASSIST PLUNGER
② SHIMS
③ GOVERNOR ASSIST SPRING
④ MAIN SHAFT
⑤ TACHOMETER SHAFT
⑥ FILTER SCREEN
⑦ SHUT-DOWN VALVE
⑧ GEAR PUMP
⑨ PULSATION DAMPER
⑩ THROTTLE SHAFT
⑪ IDLE ADJUSTING SCREW
⑫ IDLE SPRING
⑬ GEAR PUMP PRESSURE
⑭ FUEL MANIFOLD PRESSURE
⑮ IDLE PRESSURE
⑯ GOVERNOR WEIGHTS

Figure 2-6. Cummins PT fuel system.

throttle is in the idle position, the throttling hole in the shaft is not indexed with the main governor barrel port.

From the throttle, fuel flows through drilled passages in the housing to the shutdown valve. The shutdown valve is a solenoid-type valve. When the solenoid is energized, the shutdown valve opens and allows fuel to flow to the injectors. When the shutdown valve is deenergized, it closes and stops fuel flow to the injectors. This arrangement allows the engine to be shutoff by turning a key. The shutdown valve is equipped with a manually controlled knob to permit the engine to be started in case of electrical system failure.

Fuel injectors. The purpose of the fuel injectors used on the Cummins diesel engine is to meter and inject the fuel into the combustion chamber. Refer to figure 2-7 for a cross sectional view of one type of a Cummins fuel injector showing its components. Fuel is supplied to and drained from the fuel injectors through external fuel lines and connections. From the inlet connection, fuel flows down the inlet passage of the injector, around the injector plunger, between the body and cup, and up to the drain passage, as shown in figure 2-7 (start-up stroke). From the drain passage, fuel flows through the drain connections and lines back to the supply tank.

As the plunger rises, figure 2-8 (metering), the metering orifice is uncovered and part of the fuel is metered into the cup. At the same time the rest of the fuel flows out the drain orifice. The amount of fuel passing through the metering orifice and into the cup is controlled by the fuel pressure developed by the fuel pump.

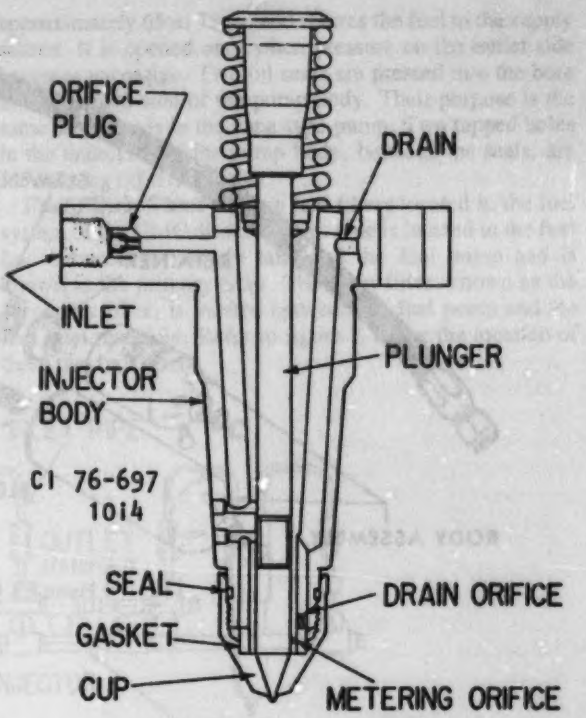
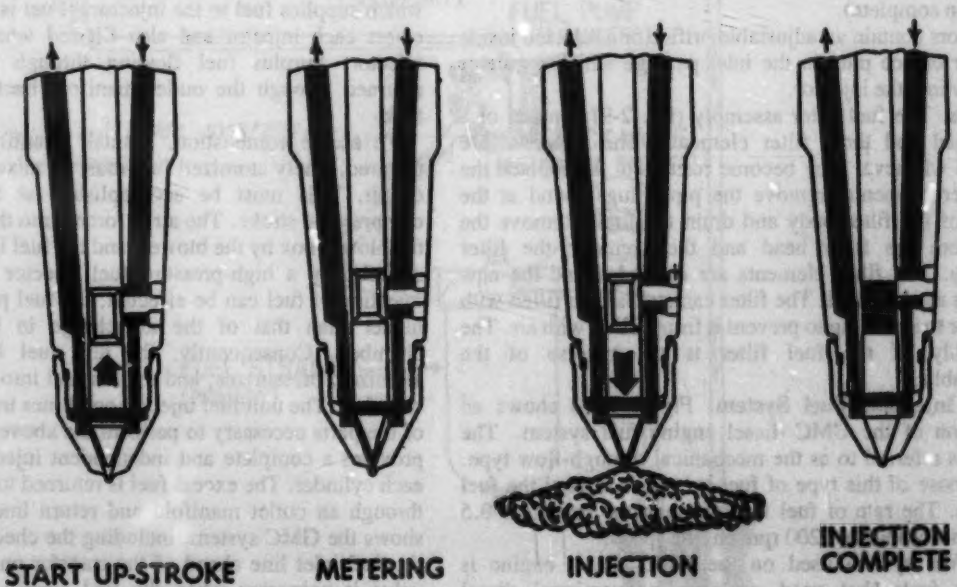


Figure 2-7. Cummins flanged injector assembly.



Cummins Fuel Injection Cycle.

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Figure 2-8. Cummins fuel injector cycle.

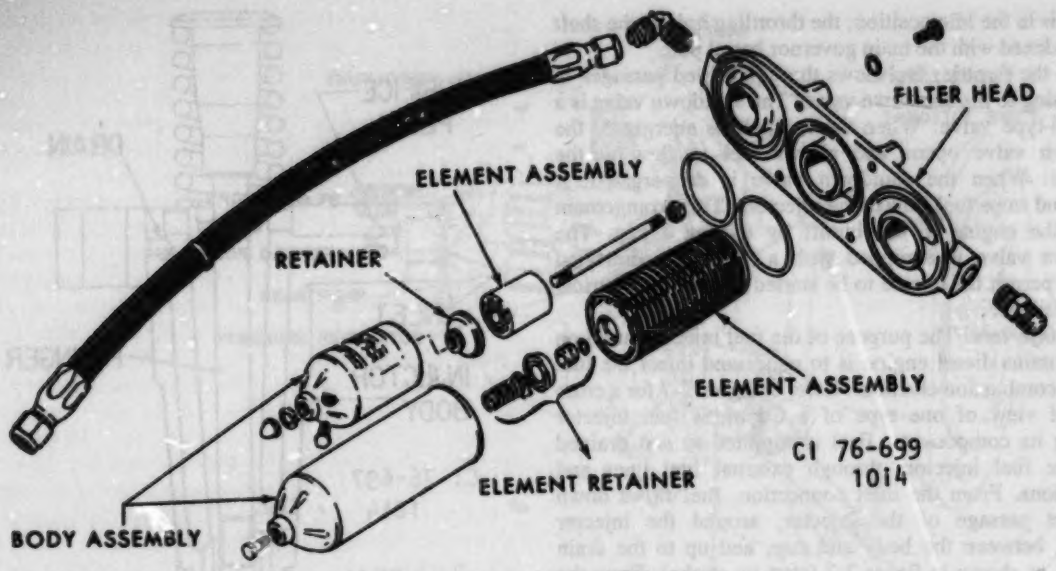


Figure 2-9. Fuel filter assembly.

As the plunger is forced down, the metering orifice is closed. Refer to figure 2-8 (injection). As the plunger closes the metering orifice, the fuel is trapped in the cup and forced into the cylinder. While the plunger is seated, all fuel flow through the injector stops. Refer to figure 2-8 (injection complete).

Injectors contain an adjustable orifice or a selected inside diameter orifice plug in the inlet passage which regulates fuel flow into the injector.

Filters. The fuel filter assembly (fig. 2-9) consists of a filter head and three filter elements. The elements are replaced whenever they become restricted. To replace the fuel filter elements, remove the pipe plugs found at the bottom of the filter body and drain the fuel. Remove the bolts from the filter head and then remove the filter assembly. The filter elements are discarded and the new elements are installed. The filter canister is then filled with fuel prior to installing to prevent it from filling with air. The reassembly of the fuel filter is the reverse of the disassembly.

Unit Injection Fuel System. Figure 2-10 shows an illustration of the GMC diesel engine fuel system. The system is referred to as the mechanical through-flow type. The purpose of this type of fuel system is to cool the fuel injectors. The rate of fuel flow through the system is 0.5 gallons per minute at 1200 rpm engine speed.

The fuel system used on the GMC diesel engine is different from that used on most conventional diesel engines. There are several reasons for this, one being that the fuel is used to help cool the engine. This engine, because of the greater number of power impulse crankshaft revolutions, would otherwise become overheated, except for the additional cooling features built into it.

Included in the fuel system are the injectors, fuel pump, fuel filters, and fuel manifolds. Fuel is drawn from a source of supply through the primary filter by the fuel or transfer pump. This pump is driven from the rear end of the blower's lower rotor shaft. From the pump, fuel is pumped through the secondary filter to the fuel intake manifold which supplies fuel to the injectors. Fuel is filtered when it enters each injector and also filtered when leaving each injector. Surplus fuel flowing through the injector is returned through the outlet manifold back to the supply tank.

To secure combustion, a small quantity of accurately metered, finely atomized fuel must be mixed with a charge of air. This must be accomplished at the end of the compression stroke. The air is forced into the cylinder from the blower box by the blower, and the fuel is forced into the cylinder by a high-pressure fuel injector device. Before injection of fuel can be effected, the fuel pressure must be higher than that of the air charge in the combustion chamber. Consequently, the unit fuel injector injects, atomizes, pressurizes, and meters fuel into the combustion chamber. The unit fuel injector combines in a single unit all of the parts necessary to perform the above functions. This provides a complete and independent injection system for each cylinder. The excess fuel is returned to the supply tank through an outlet manifold and return lines. Figure 2-10 shows the GMC system, including the check valve used in the fuel inlet line ahead of the transfer pump. This check valve is necessary when the fuel supply tank is located lower than the engine. The purpose of this check valve is to prevent fuel from draining back into the tank when the engine is shut down.

Transfer pump. On the older GMC diesel engines, a vane-type of pump is mounted on the rear of the blower housing. It has two spring-loaded vanes carried in the rotor.

These vanes and rotor revolve inside the eccentric housing and displace fuel from the inlet port to the outlet port. There are two seals inside the flange at the inner end of the rotor shaft; one retains the fuel under pressure, the other prevents the lubrication oil in the blower timing gear compartment from creeping along the pump shaft. A spring-loaded relief valve is located in the cover of the pump. This valve relieves excessive pump pressure, should any of the fuel lines or filters become clogged. If the pressure exceeds the spring setting, the valve opens and allows fuel flow from the discharge side to the inlet side of the pump.

On later model GMC diesel engines, a gear-type pump is used. This is also a positive displacement pump. It incorporates a spring-loaded relief valve, which opens at approximately 65 to 75 psi and returns the fuel to the supply source. It is opened only when pressure on the outlet side becomes excessive. Two oil seals are pressed into the bore in the flanged side of the pump body. Their purpose is the same as the seals in the vane-type pump. Two tapped holes in the underside of the pump body, between the seals, are for draining off any leakage.

Fuel filters. There are two fuel filters located in the fuel system of the GMC diesel engine. One is located in the fuel line between the supply tank and the fuel pump and is known as the primary filter. The other filter, known as the secondary filter, is located between the fuel pump and the fuel inlet manifold. Refer to figure 2-10 for the location of these two fuel filters.

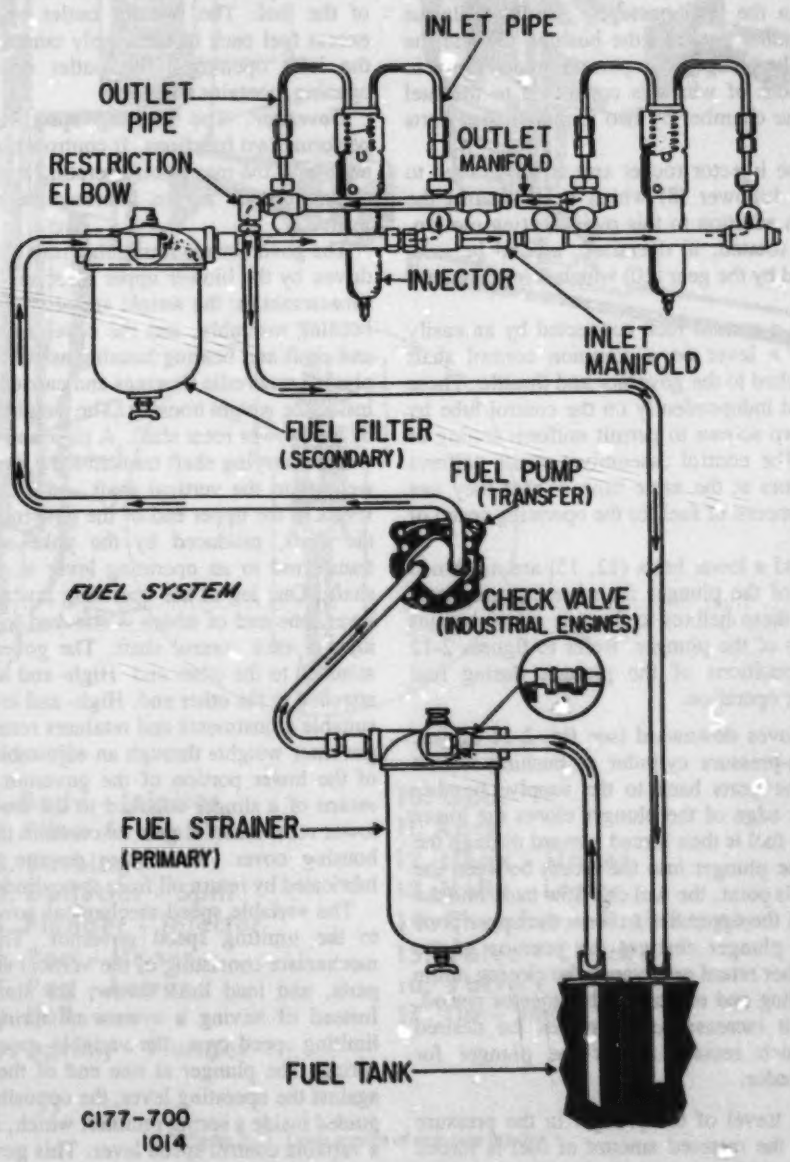


Figure 2-10. GMC diesel fuel system.

Fuel injectors. Before fuel can be injected into the combustion chamber, the fuel pressure must be higher than that of the air charge in the combustion chamber. Thus, the fuel injector performs the following: injects the fuel, meters the fuel, creates a high-fuel pressure, and atomizes the fuel. Continuous bypass of fuel through the injector body acts as a coolant and eliminates air pockets. The unit fuel injector combines in a single unit all the parts necessary to perform the above functions. This provides a complete and independent injection system for each engine cylinder.

Figure 2-11 shows a sectional view of the injector. Refer to it as you study the flow of fuel through the injector assembly. Diesel fuel is supplied to the injector under pressure supplied by the fuel pump (transfer). The fuel then enters the steel body (1) of the injector at the top through the filter element (2) in the inlet passage. The fuel fills the annular supply chamber between the bushing (3) and the spill defector (4). The plunger (5) operates up and down in this bushing, the bore of which is connected to the fuel supply in the annular chamber by two funnel-shaped ports (6,7).

The motion of the injector rocket arm is transmitted to the plunger by the follower (8) which bears against the return spring (9). In addition to this reciprocating motion, the plunger can be rotated, in operation, around its axis. This is accomplished by the gear (10) which is in mesh with the rack (11).

Each injector has a control rack connected by an easily detachable joint to a lever on a common control shaft which, in turn, is linked to the governor and throttle. These levers can be rotated independently on the control tube by the adjustment of two screws to permit uniform setting of all injector racks. The control assembly permits uniform control of all injectors at the same time so that they can deliver the correct amount of fuel for the operating speed of the engine.

An upper helix and a lower helix (12, 13) are machined into the lower end of the plunger for metering purposes. The relationship of these helixes to the two ports changes with the relationship of the plunger. Refer to figures 2-12 and 2-13 for the positions of the plunger during fuel metering and injector operation.

As the plunger moves downward (see fig 2-11 again), the fuel in the high-pressure cylinder or bushing is first displaced through the ports back to the supply chamber (14), until the lower edge of the plunger closes the lower port. The remaining fuel is then forced upward through the central passage in the plunger into the recess between the two helixes. From this point, the fuel can flow back into the supply chamber until the upper helix closes the upper port. The rotation of the plunger changes the position of the helixes. This will either retard or advance the closing of the ports and the beginning and ending of the injector period. At the same time, it increases or decreases the desired amount of fuel which remains under the plunger for injection into the cylinder.

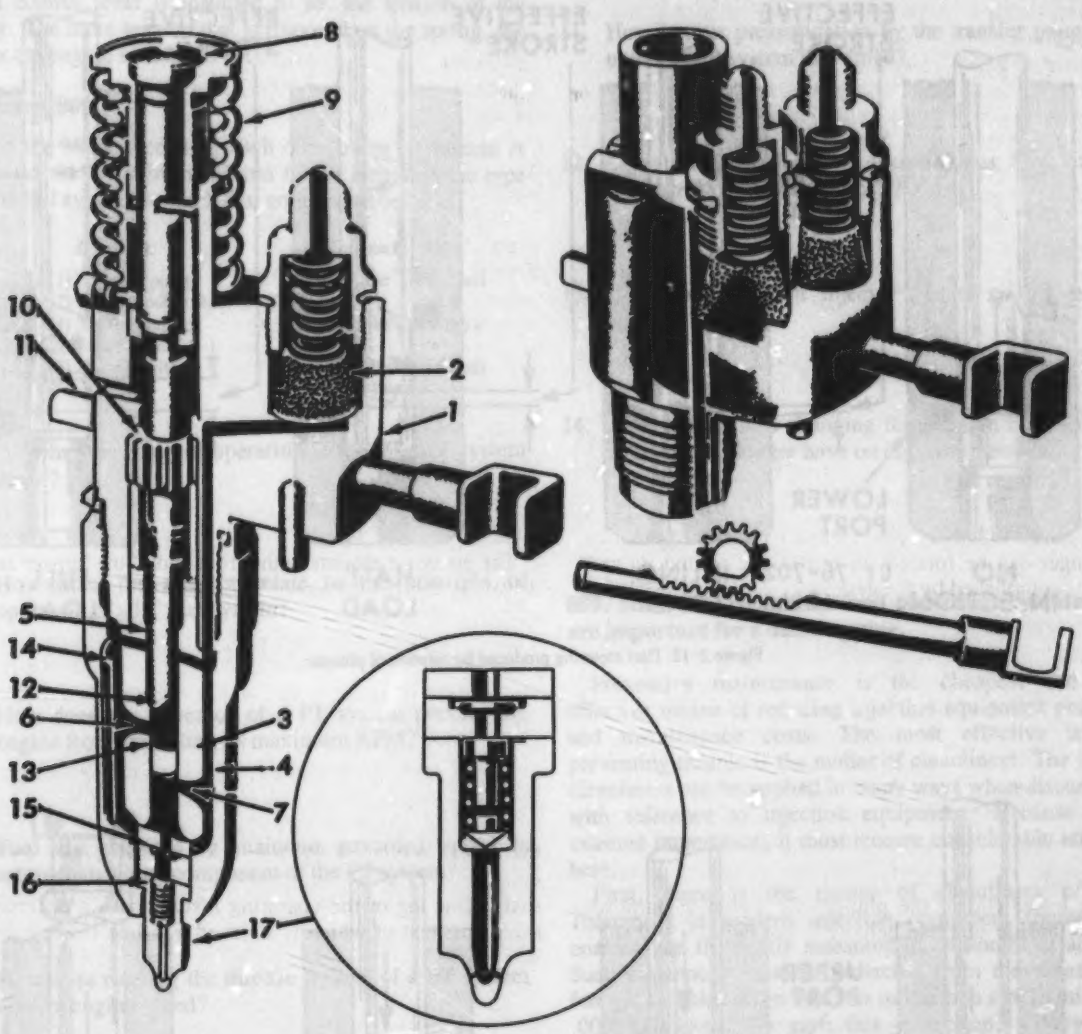
On the downward travel of the plunger in the pressure cylinder or bushing, the metered amount of fuel is forced through the valve assembly, through the check valve (15), and against the spray tip valve (16). When sufficient fuel pressure is built up, the spray tip valve is lifted off its seat and the fuel is forced through small orifices in the spray tip (17) (fig. 2-11) and atomized in the combustion chamber. The check valve prevents air leakage from the combustion chamber into the fuel system in case the spray tip valve is held open by a small particle of dirt. This allows the injector to continue to operate until the particle works through the valve.

On the return upward movement of the plunger, the high-pressure cylinder is again filled with fuel through the ports; the constant circulation of fresh, cool fuel through the injectors renews the fuel supply in the chamber and helps maintain an even operating temperature of the injectors. This flow of fuel will effectively remove all traces of air which might otherwise interfere with the accurate metering of the fuel. The injector outlet opening, which returns excess fuel back to the supply tank, is directly adjacent to the inlet opening. The outlet opening, like the inlet opening, contains a filter.

Governor. The limiting speed mechanical governor performs two functions. It controls the engine idling speed and limits the maximum operating speed of the engine. The engine speeds in the intermediate range are controlled manually.

The governor mounts to the front end of the blower and is driven by the blower upper rotor shaft. It consists of three subassemblies: the weight and shaft assembles, the bearing housing assembly, and the cover assembly. In the weight and shaft and bearing housing assemblies, two weights are pivoted on needle bearings and carried on a horizontal shaft inside the weight housing. The weight carrier shaft is driven by the blower rotor shaft. A riser and thrust bearing on the weight carrying shaft transmits the motion of the revolving weights to the vertical shaft and a system of springs and levers in the upper end of the governor housing. Motion to the shaft, produced by the yoke at the lower end, is transferred to an operating lever at the upper end of the shaft. One leg of the operating lever carries a differential lever, one end of which is attached to a link leading to the injector rack control shaft. The governor throttle shaft is attached to the other end. High- and low-speed springs are attached to the other end. High- and low-speed springs with suitable adjustments and retainers restrict movement of the governor weights through an adjustable screw. Lubrication of the lower portion of the governor is accomplished by means of a slinger attached to the front end of the blower lower rotor shaft. It gets its oil from the well in the blower housing cover. The upper portion of the governor is lubricated by return oil from the cylinder head.

The variable speed mechanical governor is very similar to the limiting speed governor. The governor linkage mechanism consisting of the vertical shaft, bearings, allied parts, and load limit screw, are similar for both types. Instead of having a system of springs, as found in the limiting speed type, the variable speed type has only one spring. The plunger at one end of the single spring bears against the operating lever; the opposite end is retained and guided inside a spring retainer, which, in turn, bears against a variable control speed lever. This governor is designed to control the engine speed at a constant speed at any point that the operator may desire, within the limitations of the



1. Body - Injector
2. Filter Assembly
3. Bushing
4. Deflector - Spill
5. Plunger - Injector
6. Port - Upper
7. Port - Lower
8. Follower
9. Spring - Plunger
10. Gear
11. Rack
12. Helix - Upper
13. Helix - Lower
14. Chamber - Fuel Supply
15. Valve - Check
16. Valve - Spray Tip
17. Tip - Spray

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Figure 2-11. Cross section of unit-type injector.

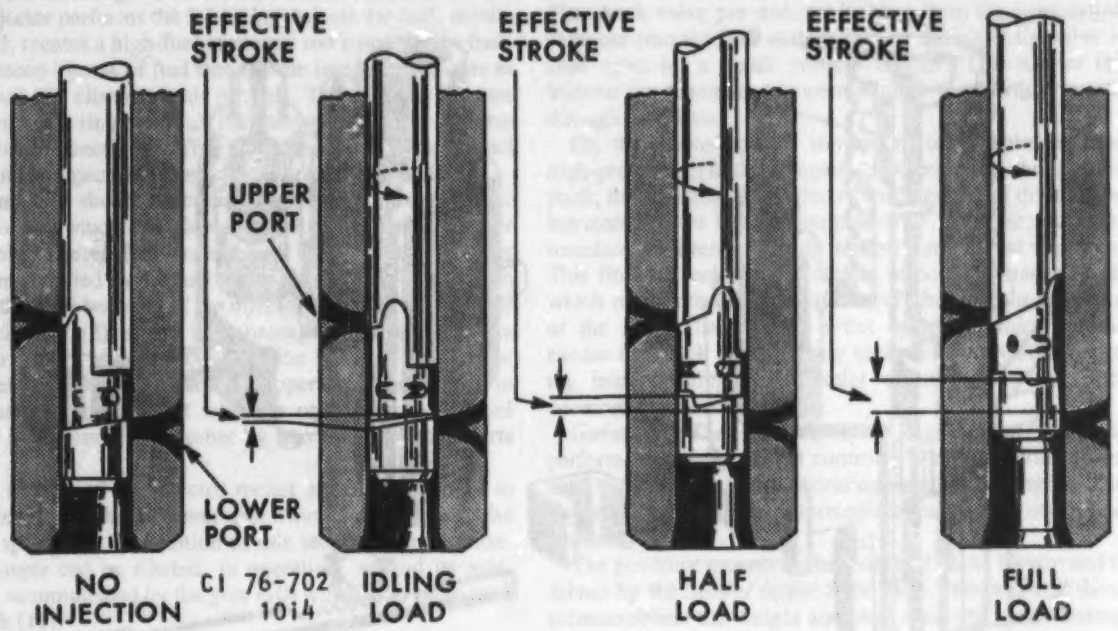


Figure 2–12. Fuel metering produced by rotation of plunger.

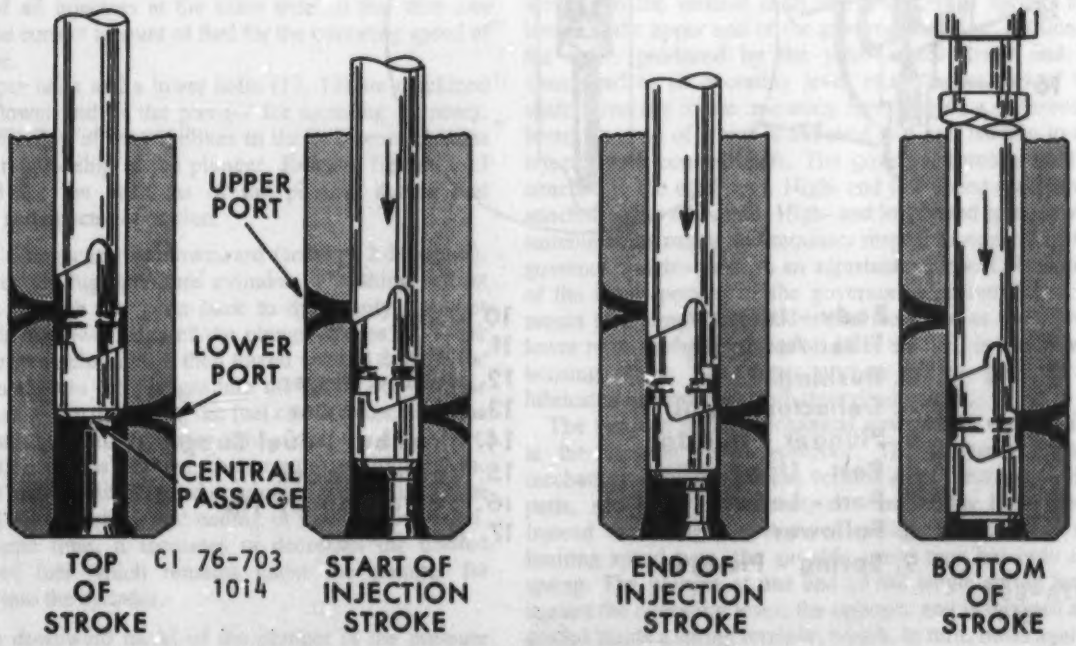


Figure 2–13. Phases of injector operation by vertical travel of plunger.

governor spring. This control is made possible by adjusting the idle screw for the low engine speed, and imposing more or less tension on the spring for higher speeds. A variable speed control lever is installed to set the tension of the spring. The more tension that is imposed on the spring, the higher the engine speed will be.

Exercises (808):

1. In the blank preceding each component in column A enter the letter from column B that identifies the type of fuel system to which that component belongs.

Column A	*Column B*
____ (1) Transfer pump.	a. Pressure-time (PT fuel system).
____ (2) Injector outlet pipe.	b. Unit injection fuel system.
____ (3) Rack assembly.	c. Both PT and unit and unit injection systems.
____ (4) Drain orifice.	
____ (5) Primary filter.	

2. On what principle of operation is the PT fuel system based?

3. How does the injector relate to the principle of operation of a PT fuel system?

4. How does the governor of a PT system prevent the engine from exceeding its maximum RPM?

5. Fuel not required to maintain governed speed is returned to which component of the PT system?

6. How does rotating the throttle control of a PT system control engine speed?

7. What determines the amount of fuel forced into the combustion chamber of a PT system?

8. Why is the unit injection fuel system referred to as a mechanical through flow type?

9. List the four filters employed in the unit injector fuel system.

10. What are the functions of the fuel injector?

11. How is over pressurization by the transfer pump of a unit injector system prevented?

12. What are the effects of a continuous flow of fuel through the unit injector body?

13. How does the unit injector system control engine speed?

14. What effect does changing the position of helixes by rotating the plunger have on injector operation?

809. State why cleanliness and preventive maintenance are important for a diesel engine.

Preventive maintenance is the cheapest and most effective means of reducing injection equipment problems and maintenance costs. The most effective way of preventing trouble is the matter of cleanliness. The idea of cleanliness can be applied in many ways when discussing it with reference to injection equipment. Because of its extreme importance, it must receive considerable attention here.

First, there is the matter of cleanliness of fuel. Tolerances in modern injection equipment (pumps and nozzles) are frequently measured in millionths of an inch. Such clearances must be protected from the abrasion of foreign particles down to a few microns in size (a micron is .0003937 inch). To give this protection, a very good filtering system must be used in the fuel systems. Most fuel systems use a series of filters having progressively higher density. Although the very best of filtering systems may be used in a fuel system, they will do no good if they are not serviced properly. Also, the best filtering systems cannot protect the system if fuel is carelessly handled.

NOTE: Improper fuel, even though clean, can destroy diesel engine fuel system components.

There are other ways in which dirt can enter the fuel system. Many times it is the fault of a careless repairman. It will be your job to change components in these systems. These jobs are not always done under ideal conditions and, even under the best conditions, it is very easy for dirt to enter during this type of work. The repairman must be very careful. In removing any fuel injection equipment, be sure that the outside portions are clean. As soon as lines are removed, cover and/or plug the ends. Keep dirt out of the system during handling.

Cleanliness of tools, bench, hands, and clothing is a must when you are working on a fuel system component. While precision parts are exposed, dirt from the above-mentioned sources will enter the most unlikely places to give trouble at some future time.

Overall cleanliness will do more than any other single thing in keeping injection equipment operating efficiently and at low cost. If you compare the term "cleanliness" with what it means to a doctor and what it means to a railroad man, in your work lean more to the doctor's meaning than to the other extreme.

Exercises (809):

1. How do foreign particles in the fuel system affect the operation of the fuel injection?

2. Explain how preventive maintenance is one of the most effective means of reducing equipment problems and maintenance cost.

810. State how to perform a compression check and how to locate a misfiring cylinder.

The experienced technician will tell you that the best approach to troubleshooting is to work with equipment that is operating. That is, using your sense of hearing, sight, and smell, you can identify the major problem quickly. But it is just as important for you to find the cause and make both repairs while you are at it. The basis of your reputation as a technician will rest on the quality of the work that you perform. Therefore, take that extra step and do it right.

Checking Compression Pressure. Like the gasoline engine, if compression is bad, none of the systems will function properly. The compression on any one cylinder should not be less than 400 psi with the engine running at 600 rpm between any cylinders of the engine.

To perform a compression test, start the engine and run it until a normal operating temperature is reached. With the engine stopped, remove the number 1 injector and install an adapter and pressure gage.

Use one of the two fuel pipes as a jumper connection between the fuel inlet and return manifolds to permit the fuel to flow directly to the return manifold. Start the engine and run it at 600 rpm. Observe and record the compression pressure indicated on the gage.

Perform the compression check on the remaining cylinders as outlined in the above procedure. After all cylinders have been checked, compare the readings. If pressure is too low or if there is a variation of more than 25 psi between cylinders, refer to the applicable technical publication for the trouble and remedy.

Misfiring Cylinder. Although there are many field methods of locating a misfiring cylinder, the following method is very efficient. During your study of gasoline engines, you learn that by using a screwdriver and short circuiting a spark plug, a misfiring cylinder could be located very easily. A procedure similar to this may be used to locate a misfiring cylinder on the diesel engine. This may sound very strange at this time because we have already learned during our studies that the diesel engine has no spark plugs. However, short circuiting the flow of fuel to a cylinder has the same effect.

Run the engine until it reaches operating temperature. Then, with the valve cover removed and the engine running at idle speed, hold the number 1 injector follower down (closed) with a screwdriver. This prevents operation of the injector and no fuel is delivered to the engine. At this time, if the cylinder is misfiring, no noticeable change will take place in the engine operation. If the cylinder has been firing, there will be a noticeable change in the engine operation. Repeat this procedure for the remaining cylinders. If an injector is misfiring but the injector operating mechanism of the faculty cylinder is functioning properly, remove the injector and install a new one.

Exercises (810):

1. How should you perform a compression check?

2. How should you locate a misfiring cylinder?

Generator Set

THE AVERAGE aircraft spends the majority of its life not in the air, but on the ground. As an AGE mechanic, your job is to insure that the aircraft maintenance personnel have the necessary support equipment when they need it. One item which is required almost automatically is the generator set. As soon as the aircraft lands, the preparation for the next flight begins. The systems are checked, repaired as necessary, and inspected. For many types of maintenance, electrical power is required to check the system, operate lights and indicators, and, in many cases, operate test equipment. Most modern aircraft cannot be refueled without electrical power to the refueling system and indicators.

If you were to prepare a report on the use of AGE equipment, you would find that the engine-driven generator set recorded a higher number of operating hours than any other type of equipment. This is not to detract from the importance of other units such as air compressors, hydraulic test stands, air conditioners, heaters, or any of the other types of equipment. They are all important, but the generator set has always recorded the greatest amount of operating time.

You will find that maintenance on the generator set will consume a large percentage of your maintenance time. Obviously, a unit which is run more often than others will require more maintenance. In order to perform any level of maintenance, you must first understand the systems which control the operation of the unit.

Most generator sets are very similar in the operation of their AC and DC systems. All have about the same type of systems. The only real difference in the various types of generator sets is in the control and protective devices used in the systems.

The A/M32A-86 generator set is a relatively recent addition to the AGE inventory. This unit not only incorporates standard control components used on other generator sets but also has many components never used on other equipment. Once you have mastered the system of this unit, you should have little difficulty applying this knowledge to almost any other generating unit. For this reason, the A/M32A-86 diesel engine-driven generator set will be used throughout this chapter as our representative unit. Using the common terminology of the AGE career field, we shall hereafter refer to this unit as simply the "-86."

3-1. Generator System Description

The A/M32A-86 diesel engine-driven generator is a self-contained unit capable of supplying electrical outputs which are compatible to the aircraft systems. The prime mover consists of a four-cylinder, in-line diesel engine. Although there are many models of diesel engine-driven generator sets, their systems and components are basically the same.

The purpose of the generator set is to generate 400-Hz, 115/200-V, 3-ph power to an aircraft for operation of the aircraft's electrical equipment when the on-board generators are not running. The unit is operable when provided with fuel and 12-VDC power (supplied by the batteries). The engine, generator, and controls are designed into a compact unit which is easily removable from a tow trailer. Since we covered diesel engines in the last chapter, we will spend most of our time on the electrical system (engine and generator).

811. State the purpose and location of components on the -86 generator set.

Engine Control Panel. The engine control panel is located on the lower left side, toward the rear of the unit, below the generator control box. It includes the following components:

Engine starter switch. The engine starter switch is located in the lower center of the engine control panel. It is a momentary contact, push button switch, which connects power to an auxiliary solenoid switch, which supplies power to the starting circuit.

Engine stop control. The engine stop control is located in the lower right of the engine control panel. It is a T-handle, push-pull cable control which is connected to the engine fuel rack lever. Pulling the control outward places the rack in the NO FUEL position.

Engine generator control switch. The engine generator control switch is located in the upper left center of the engine control panel. It is a three-position toggle switch. It is spring-loaded in the BUILD-UP position which supplies power to the electric governor control box, allowing the engine to operate at normal governed speed, and it momentarily supplies current for closing the excitation deenergization relay contacts, to make 115-volt AC power

available for excitation of the generator exciter. The switch automatically returns to the GENERATOR position which maintains power to the governor control box and excitation relay. In the IDLE position, power is disconnected so that the engine returns to idle speed and the exciter field is deenergized.

Panel light and switch. The panel light and switch are located in the upper left side of the engine control panel. The shielded light is controlled by the two-position toggle switch, which also controls the panel light on the generator control box.

Load contactor control switch. The load contractor control switch is located in the upper center of the engine control panel. It is a three-position toggle switch. It is spring-loaded in the CLOSE position, which supplies power to the rectifier, closing the load contactor. It returns to the ON position and continues to supply power to the rectifier in this position. In the OFF position, power is cut off and load contactor opens.

Load contactor indicating light. The load contactor indication light is located in the upper right of the engine control panel. It is a green light which glows when the load contactor is closed and power is available at the output terminal board.

24-V power supply switch. The 24-V power supply switch is located in the lower left side of the engine control panel. The toggle switch is equipped with a hinged guard, which insures that the power supply is OFF when the guard is closed, covering the switch. When the toggle switch is in the UP position, 24-VDC power is present on terminal E of the output terminal board.

Engine protective circuit indicating light. The engine protective circuit indicating light is located in the lower center of the engine control panel. It is a green light which glows only when the engine is running and fuel pressure is sufficient to close a fuel pressure switch. The purpose of the pressure switch is to deactiviate the protective circuit, to prevent battery discharge when the engine is stopped.

Air service indicator. The air service indicator is located in the center right portion of the engine control panel. It is a glass-enclosed viewing chamber containing a red cylindrical "flag" which rises as the air pressure drops below the outside air pressure. When the "flag" reaches the top of the viewing chamber, it locks into position, notifying the operator that the air filter element must be changed. The flag is reset by pushing the reset button at the bottom of the indicator.

Ether start system control (Quick Start). The ether start system control is located in the upper right side of the engine control panel. It is a push-pull cable control, which operates a group of items designed to inject a highly volatile fluid into the air intake system to aid in cold weather starting. Pulling the control outward allows fluid to enter a valve. Pushing the control inward forces the fluid through an atomizer, into the air inlet housing of the engine.

NOTE: Other components found on the engine control panel, such as the fuel gage, ammeter, hourmeter, oil pressure gage, and temperature gage, will not be discussed because of their simplicity and wide use throughout the AGE field.

Control Box Assembly. The control box assembly is located in the upper left side of the unit, toward the rear, and above the engine control panel. It contains the generator control tray and the protective relay tray. A shielded instrument panel light is mounted on the left side of the control box front panel, to illuminate controls and instruments on the trays.

Frequency adjustment. A frequency adjustment is located on the left side of the control box front panel, above the instrument panel light. The adjustment screw is turned clockwise to increase frequency and counterclockwise to decrease the frequency, as indicated on the frequency meter in the generator control tray.

Generator control tray. The generator control tray contains instruments and controls for monitoring and controlling the generator output. The following components are located on the generator control tray and will not be discussed because of their simplicity: frequency meter, voltmeter, ammeter, meter selector switch, line selector switch, automatic-manual voltage control switch, and the manual voltage control rheostat.

Protective relays tray. The bottom tray in the control box is identified as the protective relay tray and contains electrical and electronic safety devices designed to protect the aircraft electrical system against damage which could result from overvoltage, undervoltage, overfrequency, or underfrequency. The tray also contains devices for the protection and control of the generator output electrical system.

Fault indicating lights. The function of these red lights is to indicate to the operator the abnormal condition of overvoltage, underfrequency, and other similar abnormalities, which caused the protective monitor system to function. Each of the five lights is connected to an actuating circuit within the memory and time delay module. When one of the circuits is activated, it turns on the applicable indicating light.

a. Overload indicating light. Overload circuit trips, causing the light to come on, at any value over 125 percent rated load capacity.

b. Underfrequency indicating light. Underfrequency trips, causing the light to come on at 375 to 385 Hz.

c. Overfrequency indicating light. Overfrequency trips causing the light to come on at 415 to 425 Hz.

d. Undervoltage indicating light. Undervoltage trips causing the light to come on at 102 V or below.

e. Overvoltage indicating light. Overvoltage trips causing the light to come on at 130 to 134 V.

Reset switch. The reset switch provides a means of turning off the fault indicating lights if an abnormal condition causes them to come on.

Light test switch. The light test switch provides a means of testing if the fault indicating lights will illuminate when the switch is depressed.

Exercises (811):

1. What component supplies power to the electric governor control box?

2. What component is connected to the engine fuel rack lever and is used to shut down the engine?

3. Where is the load contactor switch located, and what is its purpose?

4. When is power present at "E" terminal of the output terminal board?

5. Where is the automatic/manual voltage control switch located?

6. How many fault(s) indicating lights are located on the -86 generator set?

7. At what frequency(ies) will the underfrequency light illuminate?

3-2. Use of Schematic Diagrams

The schematic diagrams (commonly known as the schematics) are used when troubleshooting many systems of our AGE equipment. Contrary to popular belief, the use of a schematic diagram is not limited to electrical circuits. Any type of flow system such as air, fuel, or fluid systems, may be represented through the use of schematic diagram. However, because diesel engines were covered in the last chapter, we will only discuss the electrical system, components, and troubleshooting in the next few objectives.

812. Using the engine circuit schematic diagram, determine the purpose of the battery, starter, panel light, and run/idle circuits.

Figure 3-1 is the engine electrical diagram for this unit. We will use it as our guide to the operation of the electrical system. You should refer to this figure as we discuss the various circuits.

Battery Circuits. Power for operation of the electrical system is provided by two series-connected, 6 VDC batteries. They are connected in series, which applies 12 V throughout the circuit. BT1 and BT2 are located in the battery compartment on the left side of the unit. Battery potential is extended to start switch (S24), ammeter (M5), alternator (G4), panel light switch (S4), engine overspeed relay open contacts and receptacle P2, J8.

Start Circuit. The start switch (S24) is located on the engine-control panel and is a push button type. When pushed, it applies potential to the auxiliary starter solenoid (L10). After the solenoid L10 is energized, the L10 contact closes and applies battery potential to the starter solenoid (L9), which, in turn, energizes the starter motor (B2). Remember that none of the events mentioned above can take place if the air shutoff micro switch is open (S44).

Panel Light Circuit. The panel light switch (S4) is located on the engine control panel. It is a manually operated switch and is used to complete the circuit to the panel lights. Panel lights DS1 and DS2 are used to provide lighting for night operations of the unit. One light is located on the engine control panel and one on the generator control box.

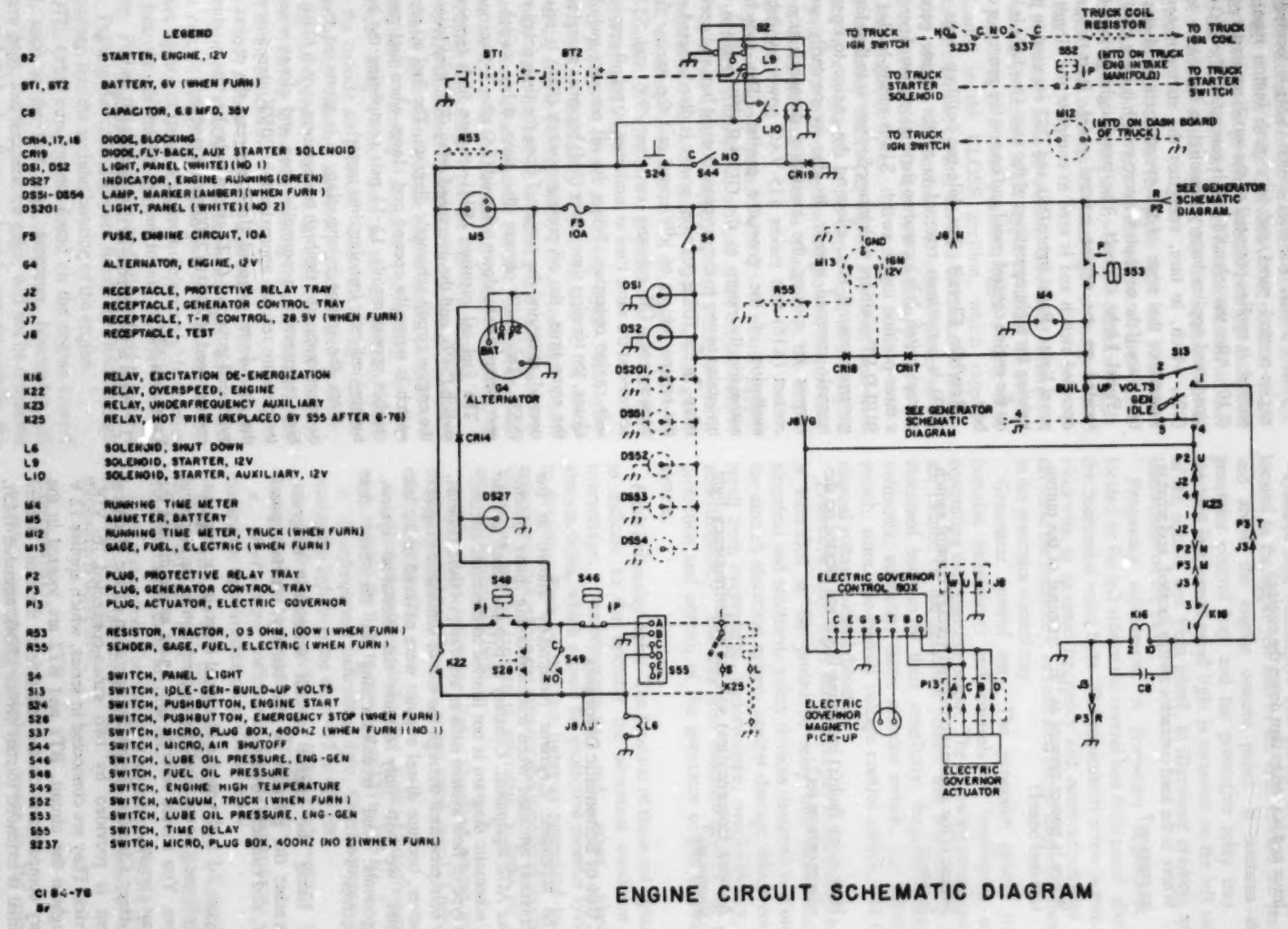
Run/Idle Circuit. The idle-gen-build-up volts switch (S13) is sometimes referred to as the engine generator-control switch. It is located on the engine control panel. It is a three-position toggle switch. S13 is spring-loaded in the BUILD-UP position, which supplies power to the electronic governor control box, allowing the engine to operate at normal governed speed. It also momentarily supplies current for closing the excitation deenergization relay contact (K16) that makes 115-VAC power available for excitation of the generator exciter. The switch will automatically return to the GENERATE position which maintains power to the governor control box and excitation relay. In the IDLE position, power is disconnected so that the engine returns to idle speed and the exciter field is deenergized. Oil pressure switches, S46 and S53, are actuated at the same time at minimum 30 psi oil pressure for safe engine operation. When the oil pressure switch S53 closes, the running time meter (M4) becomes energized. At the same time, the oil pressure switch (S46) is actuated-opened, removing the potential from the time delay switch (S55). This will prevent the time delay switch from energizing the shutdown solenoid (L6) after 3–5 seconds.

The fuel oil pressure (S48), engine high temperature switch (S49), and the overspeed relay (K22) are located on the engine circuit schematic diagram. The fuel oil pressure switch is normally opened and closes when fuel pressure reaches approximately 12–14 psi, completing the engine running indicator (running time meter).

Once the engine is operating, it is protected from an overtemperature by the high temperature switch (S49). The high temperature is normally open and closes when the temperature reaches approximately 205°F, thus energizing the shut down solenoid (L6), stopping the engine. The overspeed governor (K22 engine relay) actuates when the engine speed of 2250 to 2300 rpm is reached.

Exercises (812):

1. What is the purpose of the battery circuit?



ENGINE CIRCUIT SCHEMATIC DIAGRAM

Figure 3–1. Engine electrical diagram.

2. What type and how many battery(ies) are utilized on the −86 generator set?

3. What is the purpose of the start circuit?

4. When the start switch is actuated, what is the first component that is energized?

5. What is the purpose of the panel light circuit?

6. Where are the panel lights located?

7. What type switch is the idle-gen-build-up volts switch?

8. What position is this switch (S13) spring-loaded to?

9. What is the purpose of the idle-gen-build-up switch?

10. When is the running time meter (M4) actuated on the −86 generator set?

813. Using the generator schematic diagram (fig. 3-2), explain the purpose of the various circuits.

AC Generator Output Circuit. The output circuit provides power to the contacts of the AC load contactor relay K1. When the contactor switch S5 is closed, K1 relay is energized, thus allowing the output to be connected to the aircraft. This circuit contains all of the components necessary for protection of the generator load circuits, either through direct connection or through current transformer.

Current Transformer. Current transformers T1, T2, and T3 are the ammeter current transformers. These three transformers lower the output load current to a lesser value of definite ration. This current will operate the ammeter movement without damage. Current transformers T4, T5, and T6 are used to feed the voltage regulator for line-drop compensation. The line-drop compensation on-off switch must be in the ON position when adjusting the voltage regulation. Current transformers T7, T8, and T9 are used to sense generator's overload condition.

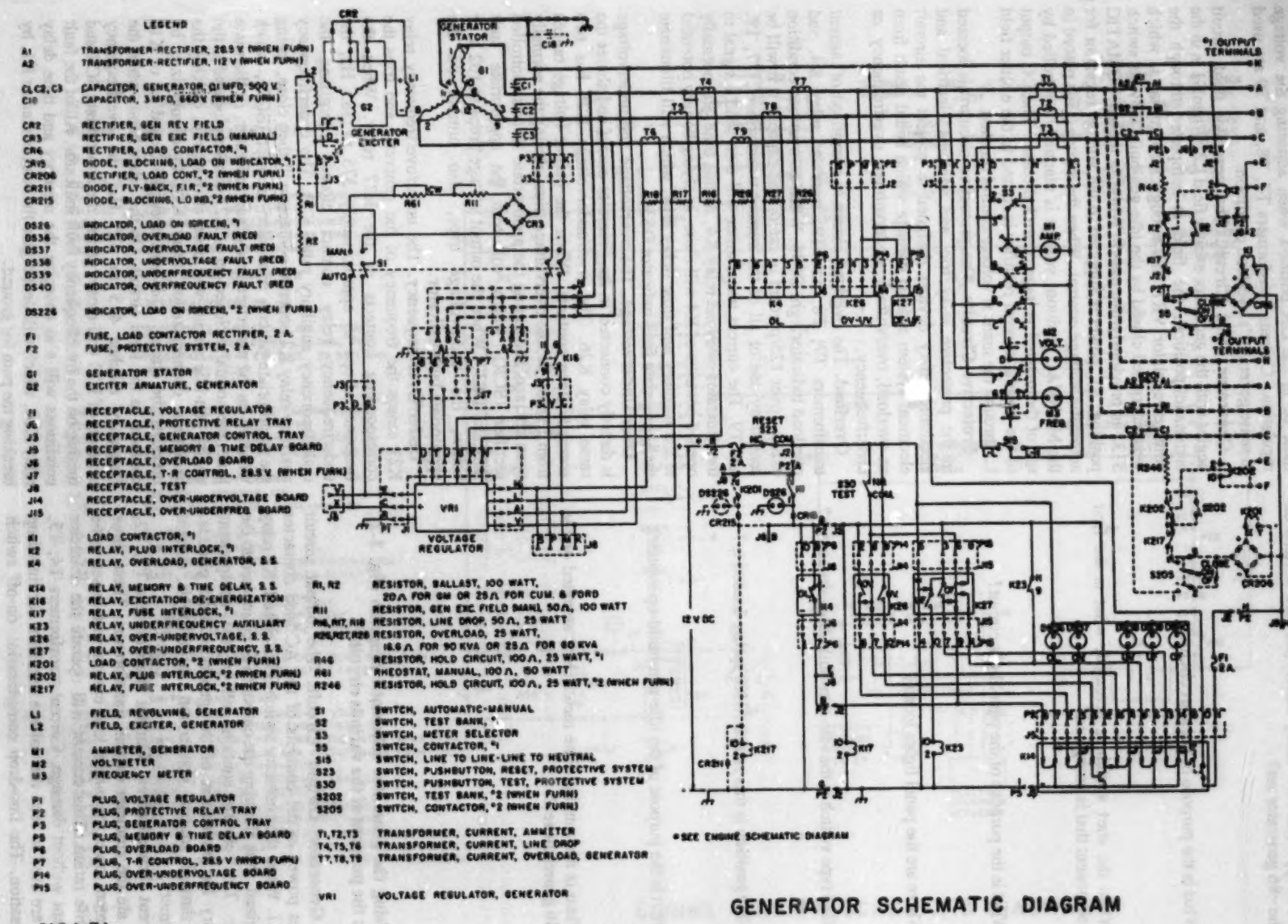
Generator Field Circuit. The generator field circuit begins with the generator exciter field L2. When S1 is in the automatic position, the field is completed through the voltage regulator VR1 and through K16 contacts, which were energized closed by the idle-gen-build up volts switch S13, as previously discussed. While in the AUTOMATIC position, AC power is supplied to the voltage regulator for automatic voltage control. When the switch S1 is placed in the MANUAL position, voltage is manually controlled by use of the manual voltage control rheostat. The DC output of the manual control rectifier is routed to the exciter field L2 through the manual voltage control rheostat.

Protective Circuits. The protective circuitry is located in the protective relay tray and contains electrical and electronic safety devices designed to protect the aircraft electrical system against damage which could result from an overload, overvoltage, undervoltage, overfrequency, or underfrequency.

Overload. The overload circuit is comprised of current transformers T7, T8, and T9, overload relay K4, and overload indicator light DS36. When an overload condition exists, (over 125 percent of rated load capacity), it will be sensed by one or all of the current transformers, T7, T8, and T9. The current transformer will then send a signal to the generator overload relay K4. At this time, the normally opened contacts of K4 will close, applying battery potential to the memory and time delay K14, which will illuminate the appropriate fault indicator DS36.

Over/Undervoltage. The overvoltage and undervoltage is directly connected to the generator output and shares the same relay K26. The over/undervoltage K26 has two normally open contacts. When the output voltage ranges from 130 to 134, the overvoltage trips, closing the normally open contacts and gating the appropriate silicon controlled rectifier (SCR), which will turn the appropriate fault indicator DS37. When the output voltage drops to 102 V or below, the undervoltage trips, also turning on the appropriate fault indicator.

Under/Overfrequency. The under/overfrequency relay K27 senses the frequency of the generator and trips the corresponding contacts of the K27 relay. When the frequency drops to approximately 375 to 385 Hz, the underfrequency relay contact closes, energizing the underfrequency auxiliary relay K23. The underfrequency auxiliary relay K23 opened contacts will then close, gating the appropriate silicon controlled rectifier (SCR), which will turn on the underfrequency fault indicator. At the same time, the normally closed set of K23 contacts located in the engine run-idle circuit will open at this time, causing the excitation deenergization relay K16 to deenergized by breaking the circuit. This will open the closed set of K16 contacts in the field circuit. On the other hand, when the frequency reaches 415 to 425 Hz, the overfrequency contacts of K23 will close, gating the appropriate SCR and turning on the overfrequency fault indicator. All of the fault conditions will also energize the memory and time delay relay K14, which will deenergize the load contactor K1, by breaking the path for ground.


LEGEND
A1 TRANSFORMER-RECTIFIER, 28.5 V (WHEN FURN.)
A2 TRANSFORMER-RECTIFIER, 112 V (WHEN FURN.)
C1, C2, C3 CAPACITOR, GENERATOR, 01 MFD, 500 V.
C10 CAPACITOR, 3 MFD, 660 V (WHEN FURN.)
CR2 RECTIFIER, GEN REV FIELD
CR3 RECTIFIER, GEN EXC FIELD (MANUAL)
CR6 RECTIFIER, LOAD CONTACTOR, *1
CR15 DIODE, BLOCKING, LOAD ON INDICATOR, *1
CR206 RECTIFIER, LOAD CONT., *2 (WHEN FURN.)
CR211 DIODE, FLY-BACK, F.I.R., *2 (WHEN FURN.)
CR215 DIODE, BLOCKING, L.O.IND., *2 (WHEN FURN.)
DS26 INDICATOR, LOAD ON (GREEN), *1
DS36 INDICATOR, OVERLOAD FAULT (RED)
DS37 INDICATOR, OVERVOLTAGE FAULT (RED)
DS38 INDICATOR, UNDERVOLTAGE FAULT (RED)
DS39 INDICATOR, UNDERFREQUENCY FAULT (RED)
DS40 INDICATOR, OVERFREQUENCY FAULT (RED)
DS226 INDICATOR, LOAD ON (GREEN), *2 (WHEN FURN.)
F1 FUSE, LOAD CONTACTOR RECTIFIER, 2 A.
F2 FUSE, PROTECTIVE SYSTEM, 2 A.
G1 GENERATOR STATOR
G2 EXCITER ARMATURE, GENERATOR
J1 RECEPTACLE, VOLTAGE REGULATOR
J2 RECEPTACLE, PROTECTIVE RELAY TRAY
J3 RECEPTACLE, GENERATOR CONTROL TRAY
J5 RECEPTACLE, MEMORY & TIME DELAY BOARD
J6 RECEPTACLE, OVERLOAD BOARD
J7 RECEPTACLE, T-R CONTROL, 28.5 V. (WHEN FURN.)
J8 RECEPTACLE, TEST
J14 RECEPTACLE, OVER-UNDERVOLTAGE BOARD
J15 RECEPTACLE, OVER-UNDERFREQ. BOARD
K1 LOAD CONTACTOR, *1
K2 RELAY, PLUG INTERLOCK, *1
K4 RELAY, OVERLOAD, GENERATOR, S.S.
K16 RELAY, MEMORY & TIME DELAY, S.S.
K18 RELAY, EXCITATION DE-ENERGIZATION
K17 RELAY, FUSE INTERLOCK, *1
K23 RELAY, UNDERFREQUENCY AUXILIARY
K26 RELAY, OVER-UNDERVOLTAGE, S.S.
K27 RELAY, OVER-UNDERFREQUENCY, S.S.
K201 LOAD CONTACTOR, *2 (WHEN FURN.)
K202 RELAY, PLUG INTERLOCK, *2 (WHEN FURN.)
K217 RELAY, FUSE INTERLOCK, *2 (WHEN FURN.)
L1 FIELD, REVOLVING, GENERATOR
L2 FIELD, EXCITER, GENERATOR
M1 AMMETER, GENERATOR
M2 VOLTMETER
M3 FREQUENCY METER
P1 PLUG, VOLTAGE REGULATOR
P2 PLUG, PROTECTIVE RELAY TRAY
P3 PLUG, GENERATOR CONTROL TRAY
P5 PLUG, MEMORY & TIME DELAY BOARD
P6 PLUG, OVERLOAD BOARD
P7 PLUG, T-R CONTROL, 28.5 V (WHEN FURN.)
P14 PLUG, OVER-UNDERVOLTAGE BOARD
P15 PLUG, OVER-UNDERFREQUENCY BOARD
R1, R2 RESISTOR, BALLAST, 100 WATT, 20 Ω FOR 6M OR 25 Ω FOR CUM. & FORD
R11 RESISTOR, GEN EXC FIELD (MAN.), 50 Ω, 100 WATT
R6, R17, R18 RESISTOR, LINE DROP, 50 Ω, 25 WATT
R26, R27, R28 RESISTOR, OVERLOAD, 25 WATT, 18.6 Ω FOR 90 KVA OR 25 Ω FOR 60 KVA
R46 RESISTOR, HOLD CIRCUIT, 100 Ω, 25 WATT, *1
R61 RHEOSTAT, MANUAL, 100 Ω, 150 WATT
R246 RESISTOR, HOLD CIRCUIT, 100 Ω, 25 WATT, *2 (WHEN FURN.)
S1 SWITCH, AUTOMATIC-MANUAL
S2 SWITCH, TEST BANK, *
S3 SWITCH, METER SELECTOR
S5 SWITCH, CONTACTOR, *1
S15 SWITCH, LINE TO LINE-LINE TO NEUTRAL
S23 SWITCH, PUSHBUTTON, RESET, PROTECTIVE SYSTEM
S30 SWITCH, PUSHBUTTON, TEST, PROTECTIVE SYSTEM
S202 SWITCH, TEST BANK, *2 (WHEN FURN.)
S205 SWITCH, CONTACTOR, *2 (WHEN FURN.)
T1, T2, T3 TRANSFORMER, CURRENT, AMMETER
T4, T5, T6 TRANSFORMER, CURRENT, LINE DROP
T7, T8, T9 TRANSFORMER, CURRENT, OVERLOAD, GENERATOR
VR1 VOLTAGE REGULATOR, GENERATOR
*SEE ENGINE SCHEMATIC DIAGRAM
GENERATOR SCHEMATIC DIAGRAM
GENERATOR STATOR
GENERATOR EXCITER
VOLTAGE REGULATOR
*1 OUTPUT TERMINALS
*2 OUTPUT TERMINALS
12 V DC
RESET
TEST
M1 AMP
M2 VOLT
M3 FREQ

CI 84-74
Br

Figure 3–2. Generator schematic diagram.

Exercises (813):

1. What is the purpose of the generator output circuit?

2. What is the purpose of the current transformers?

3. The S1 must be in what position when the voltage regulator is controlling output voltage?

4. What is the purpose of current transformers T7, T8, and T9?

5. What conditions will cause the protective circuits to activate?

6. Describe the action that should occur when the frequency of the generator output drops to 375 Hz.

814. Identify the correct, applicable procedure used in troubleshooting and correcting identifiable malfunctions in the A/M32A-86 generator system.

Troubleshooting. Troubleshooting is the orderly process of checking and eliminating possible causes of trouble until the exact cause of a trouble is found. As a rule, the best place to start looking for the cause of trouble in a circuit or system is at the source of power or supply. Continue testing or checking the circuit or system step by step, in an orderly manner, until the cause of trouble is located.

Recognition and verification. The recognition and verification steps in effective troubleshooting should be fully understood at this point.

Analysis. Analysis is probably the most difficult part of troubleshooting. However, by this time you should have learned the functions, construction, and operating principles of the generator set. By drawing upon this knowledge and using the troubleshooting chart in the technical order, you will be able to determine the system which may be causing the malfunction.

After determining the faulty system, you must determine where to begin your troubleshooting. You can do this by such means as lights glowing, a relay operating, or a pressure indication on a gauge. Let's assume a problem and use the generator schematic diagram to analyze the circuit. Our problem, the load contactor, will not close when the load contactor switch is held in the CLOSED position. First, let's look at the sequence of events that should take place. When the contactor switch S5 is placed in the CLOSED position, the load contactor relay is energized. This relay will be energized only if the ground circuit is completed through fuse F1 and K14 closed contacts. The potential for the load contactor relay K1 is provided by a connection through terminals 1 and 2 of the load contactor switch S5. This connection only provides for initial energization of the relay. The load contactor K1 relay contacts are located in A, B, and C phases for output. There is another set of normally open K1 contacts which will energize the fuse interlock relay K17. When K17 is energized, it's contacts will close, providing a hold-in for the load contactor relay K1, either through K2 or S2.

If the load contactor relay K1 does not close initially when the load contactor switch S5 is placed in the CLOSED position, then the problem will exist somewhere between terminal C2 contacts, on the off side of the load contactor relay K1, through the following components: contactor switch S5, load contactor coil, load contactor rectifier CR6, load contactor rectifier fuse F1, memory and time delay relay closed contacts K14, and to ground. That is the complete circuit for initial energization of the load contactor relay K1. Now the load contactor will energize momentarily while S5 is held closed, but opens when S5 is released. The problem now exists in the hold-in circuit. The hold-in portion of the load contactor circuit begins on the C1 contacts, on the opened side of the load contactor relay K1 through the following components; resistor R46, plug interlock relay K2, which is paralleled with the test bank switch S2. Either relay K2 or switch S2 must be actuated closed for the hold-in circuit to function. The K17 contacts must also be closed to complete the hold-in circuit, which will keep the load contactor relay closed.

Isolation and/or elimination. Our first action should be to remove and inspect the load contactor circuit fuse F1. Another action that could be taken would be to connect a jumper wire with test prods between terminals "S" and "R" on the test receptacles. The automatic-manual voltage control switch must be in the AUTOMATIC position for this test to work. As you can see, you will be applying one phase of the generator's output voltage directly to the positive side of the rectifier CR6. If the contactor still does not close, replace it.

Repair and check. Our final step is to either repair the load contactor relay K1 or replace it. Once this has been done, the unit must be operated to insure that the load contactor is closing and all other circuits and systems are properly operating.

Correcting Malfunctions. Repair is closely related to and is usually a result of troubleshooting. Certain structural and mechanical failures are visible; therefore, corrective measures are evident. Before you attempt a repair job, obtain the necessary tools, test equipment, and technical orders. Make sure all safety hazards have been eliminated and that procedures for carrying out maintenance are understood. The applicable TO will give you a detailed, sequenced procedure for removal, disassembly, and replacement of components.

If you are doing the job with an assistant, make sure he or she knows exactly what is to be done. Do not make haphazard fixes to Air Force equipment. Such assemblies as

generators, regulators, and relays should be replaced only after extensive diagnostic troubleshooting has proven that trouble exists. Guesswork troubleshooting has no place in the skills of a good mechanic.

After you have determined that a component is defective, you must decide whether or not to repair it, assuming the component is repairable. Some factors which may influence your decision are the availability or replacement parts; the feasibility of repair in regards to economy and needed parts, bits and pieces; and your shop capabilities. Allied field maintenance shops are to be considered an extension of your shop's capabilities. These specialists perform in well-equipped shops and are able to bench check and repair such items as generators, regulators, and other associated equipment.

Exercises (814):

1. After a problem has been recognized and verified, what is the next step to effective troubleshooting?

2. How can you best determine where you should start checking a circuit for a malfunction?

3. Which step of troubleshooting is considered the most difficult?

4. What is the first component you should check if the load contactor K1 failed to close during operation?

Dispatcher Vehicle Operations

MOST LARGE transportation companies control their equipment fleets with trained dispatchers. These dispatchers are responsible for having the right piece of equipment with the right driver on the right spot at the right time.

As an AGE dispatcher, you will have many types and pieces of equipment to tow in and around the shop and flightline area. You must provide prompt local pickup and delivery service.

4-1. Forms and Records

Many forms are used in vehicle operations. When these forms are completed, they become important records in your operations. Some of these completed forms are forwarded for use in the preparation of the vehicle operational reports.

815. Explain the purposes, characteristics, and uses of forms and records by vehicle operations.

The driver's file contains DD Form 1360, Motor Vehicle Operator Qualifications and Record of Licensing, Examination and Performance. At first, this form is probably the only document that will be in your file. As time goes on, other documents usually are added. Among these are accident reports, the cost of repair if you are liable for damages to an Air Force vehicle, recommendations for driver awards, and other documents that reflect on your capabilities as a driver.

DD Form 1360, Motor Vehicle Operator Qualifications and Record of Licensing, Examination and Performance. This form is established and maintained for each Air Force vehicle operator. This record is commonly called the driver's qualification record. It provides information on official qualifications, background and experience, examination findings, performance record, driver awards, traffic violations, and accidents. The DD Form 1360 is a permanent record and is forwarded to your new station each time you transfer.

Figures 4-1 and 4-2 show a completed DD Form 1360. The front of the form identifies you, the driver. It includes your description, shows your previous driving experience and license, provides a record of your physical evaluation, and gives a complete list of the results of your written tests.

Section IV provides a record of the road test results for each type of vehicle you have been tested on (fig. 4-2).

Each vehicle on which you pass the road test will be included on your operator's permit. The card number of your permit is determined locally by the vehicle's operations officer. Quite often this number consists of three parts. The first part is made up of the base initials; the second contains two numbers to show the year of issue; and the third part is a serial number determined by the order of issue. A complete permit number using this system appears as SAFB 70–428. Restrictions on the driver's permit may contain such items as valid with glasses only, valid on base, and valid for vehicles with automatic transmission.

Section V of the form is used to record your credits whenever you complete some type of training or retraining, get an award, receive a commendation, or do anything else to enhance your professional skill or standing. Debits accumulate against you for accidents, traffic violations, arrests, warnings, suspensions, and other similar demerits. Debits for moving traffic violations and for some other violations, either on or off base, vary from 1 to 12 points. These point values are specified in AFR 125–14, *Motor Vehicle Traffic Supervision*, and they apply to the operation of both Government and privately owned vehicles. Whenever debit points are assessed against you, the least you can expect is counseling by your supervisor. If you get a predetermined number of debit points, your driver's permit will be suspended or revoked. You will then have to take more training and be retested to show that you can handle a vehicle safely and competently. In case you fail to show satisfactory improvement, your permit will be revoked permanently.

Standard Form 46, U.S. Government Motor Vehicle Operator's Identification Card. Every driver of an Air Force vehicle must have a valid Standard Form 46. This operator's permit is illustrated in figure 4-3. The permit is valid indefinitely for military personnel (3 years for civil service personnel).

The possession of a driver's permit does not give you a permanent license. It can be suspended or revoked at any time. You will be re-examined to retain your license whenever: (a) you are involved in a major accident; (b) the vehicle's operations officer thinks it is necessary after a minor accident, evidence of vehicle abuse, or a display of immature judgment or attitude; (c) you receive three moving traffic violations within a 12-month period; or (d) you are affected by a physical impairment that results in a physical profile change. Your permit will be revoked: (a) when failure on re-examination is not corrected within 30

MOTOR VEHICLE OPERATOR QUALIFICATIONS AND RECORD OF LICENSING, EXAMINATION AND PERFORMANCE
(THIS FORM IS SUBJECT TO THE PRIVACY ACT OF 1974)

AUTHORITY: 10 USC 8012; 44 USC 3101; EO 9397.
PRINCIPAL PURPOSE: To record operator qualification and record of licensing, examination, and performance.
ROUTINE USE(S): Analyze driving record of individuals; determine physical profile changes since last medical examination; determine past and current driving experience; make necessary adjustments on member's driving record; determine safe driver award as prescribed in governing directives. Information may be disclosed to any DOD component and upon request, to other federal, state, and local agencies in the pursuit of their official duties. It may be used for other lawful purposes including law enforcement and litigation.
DISCLOSURE IS VOLUNTARY: If requester fails to furnish the information solicited, SF 46, US Government Motor Vehicle Operator's Identification Card, will not be issued.

NAME (Last, First, Middle Initial)	GRADE	TITLE		ORGANIZATION		
Bruhier, Astor L.	Amn	AGE Mechanic		2nd FMS AGE		
SOCIAL SECURITY NUMBER	DATE OF BIRTH	AGE	COLOR OF HAIR	COLOR OF EYES	HEIGHT	WEIGHT
FR 123-45-6789	580919	24	Black	Brown	6'2"	190

II. BACKGROUND AND EXPERIENCE

TYPE OF VEHICLE	SIZE	TYPE OF DRIVING OR OPERATION (City, rural, long haul, etc.)	DRIVER'S LICENSES (Government, State, etc.)	DATE AND PLACE QUALIFIED (Give "Date" in Yr, Mo, Day)	SATISFACTORY EXPERIENCE VERIFIED BY
Sedan	6-Pass	City & Hwy	Texas E-78641	15 Sept 1976, El Paso, Texas	Cain, Edgar L., TSgt

III. PHYSICAL EXAMINATION *(When applicant fails 1 and 2 below, refer them to medical facility)*

				DATE (Yr, Mo, Day)	RENEWAL		EXAM INITIALS	DATE (Yr, Mo, Day)
	INITIAL				PASSED	FAILED		
1. VISUAL ACUITY (Distance)	GLASSES: ☐ YES ☒ NO	RESTRICTIONS: None		W. W. Walker				
	LEFT EYE: 20/20	RIGHT EYE: 20/ 30	☒ PASSED ☐ FAILED	W. W. Walker				
2. COLOR PERCEPTION	RED, AMBER, GREEN (Tower signals, if applicable)		☒ PASSED ☐ FAILED	W. W. Walker				
3. MEDICAL REFERRAL? ☐ YES ☒ NO	RESULTS OF MEDICAL EXAMINATION							

IV. ROAD TEST *(Use for initial, renewal, or reexamination only)*

DATE (Yr, Mo, Day)	TYPE OF VEHICLE	ROAD TEST SCORE	COMMENTS, RECOMMENDATIONS AND SIGNATURE OF ROAD TEST EXAMINER
11 Mar 1978	Tractor	86	Operation satisfactory
11 Mar 1978	Pickup, 1/2-ton	84	Needs to work on backing-up

I understand the instructions received at the driver training school; state, local, and base traffic regulations; proper procedures for completing trip tickets and accident reports; and my responsibility and consequences involving negligence in failing to perform preventive maintenance to motor vehicles, or being at fault in causing accidents. I have been shown how to overcome or adjust my driving weaknesses.

DATE (Yr, Mo, Day)		SIGNATURE OF APPLICANT	
INITIAL	RENEWAL	INITIAL	RENEWAL
11 Mar 1978		Astor L. Bruhier	

DD FORM 1 SEP 76 1360 PREVIOUS EDITION IS OBSOLETE

CI 85-1081
8a

Figure 4-1. DD Form 1360 (front).

days; (b) automatically, if you have two reportable accidents within a 12-month period in which the investigation shows negligence; (c) if you get your state operator's permit suspended or revoked; or (d) whenever the vehicle's operations officer decides that there is cause for revocation.

Permits are authenticated by the vehicle's operations officer for each type of vehicle you are qualified to operate. Normally, this means all vehicles of the same chassis type up to and including those of the weight class on which you passed the road test. You must sign the permit before it is authenticated by the vehicle's operations officer.

Duplicate permits are issued to replace those lost, damaged, or stolen. Your qualification record will be checked to verify your qualifications before a duplicate is issued. If your qualifications cannot be substantiated for any reason, you will be re-examined. All such permits are marked "Duplicate."

You retain your permit when you are transferred to a new base. However, the vehicle's operations officer at the new base normally reviews your record to decide whether to re-examine you before assigning you to driving duties. You always are instructed in local traffic regulations and operating procedures at your new station. When you are discharged from the Air Force you surrender your permit so that it can be destroyed or cancelled. You can retain a cancelled permit. A Government operator's permit cannot be used in place of a state driver's license for the operation of a privately owned vehicle.

AF Form 1252, USAF Vehicle Serv-O-Plate. This form is different from other forms that you use. It is an embossed plastic plate similar to a commercial oil company credit card. It contains information to identify the vehicle and user for cost account purposes. The information embossed on the plate is the USAF registration number, USAF management code, vehicle type and manufacturer, using command code, fuel code, and if the services are reimbursable, a reimbursement code.

You use the Serv-O-Plate for three purposes. Possession of the Serv-O-Plate is your authority for driving the vehicle. If you get caught driving a vehicle without its Serv-O-Plate, you probably will be charged with vehicle misuse. Also, you must have the Serv-O-Plate to get your vehicle serviced with fuel and oil. In addition, the Serv-O-Plate is required for any maintenance work done on the vehicle.

IV. LICENSE RECORD

CARD NO. a	DATE ISSUED (Yr, Mo, Day) b	DATE EXPIRES (Yr, Mo, Day) c	ISSUED BY d	TYPE OF VEHICLE e	GROSS VEH. WT. NO. PAX, ETC. f	PRINTED NAME AND GRADE OF QUALIFYING OFFICIAL g
SAFB	780312	Indef	Shepard AFB, TX	Tractor	Farm tractor	W. W. Walker GS-9
70-126	780312	Indef	W. W. Walker	Truck, cargo	1/2 ton	W. W. Walker GS-9

V. TRAINING AND PERFORMANCE RECORD

(List chronologically as a "credit"--award, training, retraining, roadeo, etc.; and as "debit"--accident, arrest, violation, warning, revocation, suspension, etc.)

DATE (Yr, Mo, Day) a	CREDIT b	DEBIT c	TYPE OR NATURE d	ACTION TAKEN e
780310	X		Traffic Safety Courses I, II, VI	
780721		3 pts	Ran stop sign	Counselled on observation of regulatory signs and devices.

CI 85-1080
8a

Figure 4-2. DD Form 1360 (back).

Standard Form 46
Revised Jan. 1977
USCSC
FPM Chapter 930

U.S. Government Motor Vehicle Operator's Identification Card

Card No. 78-428

Name of Operator		Sex	Date Issued
Long,	Jake I.	M	2 Jan 78

Height	Weight	Date of Birth	Social Security No.	Date Expires
6'2"	215	21 Aug 40	266-60-4807	Indef

Color of Hair	Color of Eyes	HOT TRANSFERABLE Card must be carried at all times when operating Government vehicles.	Signature of Operator (Not valid unless signed)
Black	Blue		Jake I. Long

Name and Location of Issuing Unit: Sheppard AFB, Texas

Signature and Title of Issuing Official: Charles R Hoacox, Vehicle Ops Officer

The holder of this card is qualified to operate U.S. Government vehicles and/or equipment specified, subject to the restrictions set forth on the reverse of this card.

46-105

PRIVACY ACT NOTICE

Authority: This information is provided pursuant to Public Law 93-579 (Privacy Act of 1974), December 31, 1974, for individuals being issued Standard Form 46, U.S. Government Motor Vehicle Operator's Identification Card. U.S. Code, Title 5, section 301.

Purpose and Uses: The purpose of SF 46 is to identify Federal employees who have been authorized by their agencies to operate Government-owned motor vehicles.

Effects of Nondisclosure: The effect of nondisclosure of the information required on the SF 46 is that an individual will not be authorized to drive a Federal motor vehicle. Failure to disclose accurate information that results in a negative reply from the National Drivers Register Service can result in revocation of an issued operator's identification card. The disclosure of this information is mandatory when an employee's job requires driving a Federal motor vehicle and is voluntary otherwise.

Information Regarding Disclosure of Your Social Security Number Under Public Law 93-579 Section 7 (b): Disclosure by you of your Social Security Number (SSN) is

(continued on reverse)

FRONT

Restrictions: None

QUALIFIED TO OPERATE

Type Vehicle and/or Equipment	Capacity	Qualifying Official
Sedan Sta Wgn	5-9 Pass	CR Hoacox
Trk Cargo	¼-1½	CR Hoacox

OTHER RECORDS (*Optional*)

mandatory to obtain the U.S. Government Motor Vehicle Operator's Identification Card. Solicitation of the SSN by the United States Civil Service Commission is authorized under provisions of Executive Order 9397, dated November 22, 1943. The SSN is used as an identifier throughout your Federal career from the time of application through retirement.

The SSN will be used by the National Drivers Register Service in conducting a routine check of your driving record. The SSN also will be used by the Civil Service Commission and other Federal agencies in connection with lawful requests for information about you from former employers, educational institutions, financial, law enforcement, or other organizations. The information gathered through the use of the number will be used only as necessary in personnel administration processes carried out in accordance with established regulations and published notices of systems of records. The SSN also will be used for the selection of persons to be included in statistical studies of personnel management matters. The use of the SSN is made necessary because of the large number of present and former Federal employees and applicants who have identical names and birth dates, and whose identities can only be distinguished by the SSN.

BACK

CI 85-1082
8a

Figure 4-3. Standard Form 46.

Operator's Inspection Guide and Trouble Report. There are several forms used for this purpose, however, all are basically the same.) This form is used as a guide to inspect a vehicle and to report any deficiences or malfunctions discovered before, during, or after a vehicle is operated. When a vehicle needs maintenance work, the vehicle's operator submits this form and the Serv-O-Plate to the maintenance shop.

Figures 4-4 and 4-5 show how to enter discrepancies on the form. The form is valid for 1 month. The vehicle is inspected daily and each driver signs the form on the date he or she operates that vehicle and notes all malfunctions and discrepancies during the inspection. Item 19 is for those items not listed on the form. The back of the form is used to record any maintenance actions performed on the vehicle. Notice that item 19 has a status code, D.P., which means the work was deferred for parts because the sunvisor was not available. If the sunvisor is not installed by the end of the month and that action is still coded D.P., it will be carried forward to the new form used for the following month.

Exercises (815):

1. What activities keep records on an Air Force vehicle operator?

2. Name the first form in your driver's file in vehicle operations.

3. What is the purpose of DD Form 1360?

4. What happens to your DD Form 1360 when you transfer to another base?

5. What normally happens when a driver accumulates a predetermined number of points?

6. What form is used to identify personnel who are qualified to operate Air Force vehicles?

ITEMS TO BE CHECKED (CONT'D)	OPERATOR SIGNATURE	DAY
23.		23
24.		24
25.		25
26.		26
27.		27
28.		28
29.		29
30.		30
31.		31
32.		
33.		
34.		
35.		
36.		
37.		
38.		
39.		
40.		
41.		

42. SPARK CHECK (Weekly and Scheduled Inspection Intervals)

TYPE INSPECTION (Weekly or Sched)	DATE DUE	DATE ACCOMP	OPERATOR OR MECHANIC SIGNATURE AND GRADE
Weekly	2 APR	2 APR	Tommy Thompkins
Scheduled	2 APR	2 APR	Tommy Thompkins

CB2-2826
0-80

* U.S. GOVERNMENT PRINTING OFFICE: 1971—757-163

OPERATOR'S INSPECTION GUIDE AND TROUBLE REPORT

DATE (MO/YR): APRIL 78

VEHICLE TYPE: SEDAN S/C
REGISTRATION NO.: 77B1198
USING ORGANIZATION: LGTO
LOCATION: BLDG 1090
PHONE NO.: 2765
VEHICLE CONTROL OFFICER NAME: SAUNDERS, MIKE
GRADE: CAPT
PHONE NO.: 2055

ITEMS TO BE CHECKED	OPERATOR SIGNATURE	DAY
1. CLEAN VEHICLE (exterior/interior)	Rick Stearns	1
2. DAMAGE (exterior/interior/missing parts)	Bill Harriff	2
3. TIRES/SPARE/JACK/LUG WRENCH	Travis Hall	3
4. FUEL/OIL/COOLANT (level)	Ed Dalycamp	4
5. LUBE/OIL CHANGE (ck due°date)	Roy Fitzgerald	5
6. LEAKS (Fuel/water/oil)	Jake Long	6
7. BATTERY (cleanliness/fluid level)		7
8. DRIVE BELTS/PULLEYS		8
9. SAFETY DEVICES (Headrests/belts/warning lights)		9
10. INSTRUMENTS		10
11. WINDSHIELD WIPERS/WASHERS		11
12. HORN		12
13. LIGHTS (turn signal/reflectors)		13
14. CLEAN WINDOW GLASS (operator)		14
15. STEERING		15
16. BRAKES		16
17. UNUSUAL NOISE DURING OPERATION		17
18. CARGO MOUNTED EQUIPMENT		18
19. other (see back of form)		19
20.		20
21.		21
22.		22

Figure 4–4. AFTO Form 374 (front).

VEHICLE/EQUIPMENT DISCREPANCY AND MAINTENANCE REPORT

OPERATOR REPORT			REPORTED TO MAINTENANCE				MAINTENANCE CONTROL REPORT			
ITEM NO.	DISCREPANCY	DATE DISC.	DATE	TIME	MILES/ HOURS	INIT.	WORK ORDER NUMBER	DATE	STATUS[1] CODE	INIT.
19	Sunvisor Missing	020478	020478	0800	01444	RW	BZ742	78110	D.P.	RW
19	Seat (Drivers Side) Frayed	020478	020478	0800	01444	RW	BZ742	78110	W.	RW

[1] STATUS CODES: C - Corrected; C-T by Temp Fix; C-P by Perm Fix; D - Deferred; D-P for Parts; D-M for Maint; D-D for Disposition; W - Waiver of Repairs See Sec II, TO 00-20B-5

2

C182-2827
0-8a

Figure 4-5. AFTO Form 374 (back).

7. Normally, how long is an SF 46 valid for a military driver?

8. What happens to your SF 46 when you are transferred to another base?

9. What form serves as a driver's authority for having a vehicle?

10. Besides being your authority for having a vehicle, what other purpose does the Serv-O-Plate have?

11. For how long is each Operator's Inspection Guide and Trouble Report good?

12. How often must a vehicle be inspected?

4-2. Inspecting, Servicing, and Cleaning

Vehicles must be maintained in a safe and serviceable condition to provide efficient transportation service. High-quality inspections and servicing result in the availability of a high percentage of the vehicle fleet. On the other hand, poor and haphazard inspections and servicing put too many vehicles out of service.

816. Explain how to make a daily inspection of a general purpose vehicle.

Use an Operators Inspection Guide and Trouble Report (General Purpose Vehicle), to make a daily inspection on a general purpose vehicle. It serves as an inspection guide and as a place to record needed repairs.

You make a preoperational check of the vehicle to be sure it is ready and safe to operate. Start by looking for damages and leaks. Walk around the vehicle and look for damage that has occurred since the vehicle was parked. Damage can be caused by vandalism, a falling object, or collision. Don't worry about damage previously reported and recorded on the AFTO 374, but be sure to bring new damage to the attention of your supervisor. This allows an investigation to be made and prevents you from being held responsible. Also, look for missing components that could have been stolen or lost because of vibration.

Look under the vehicle for evidence of leakage. Ignore minor oil and grease drips that are the result of normal operation. You may find fuel, oil coolant, gear lubricant, or brake fluid. Fuel will have a gasoline odor. Also, fuel will soften asphalt paving and evaporate rapidly. Engine oil normally is black, oily, and thin compared to gear lubricant, which is black and thick. Coolant is water clear or greenish in color. Brake fluid normally is a clear, oily fluid with a sharp odor. Be sure to determine the type of fluid and its source. After the vehicle is started and moved, it may be very difficult to determine the location of the leak.

Look at the tires to see if they appear to be inflated normally. Check for obvious cuts or bulges, and remove any rocks or other objects lodged between dual tires. A tire apparently leaking should be changed.

Pull the dipstick and check the oil level before you start the engine. Also, remove the radiator cap and check the coolant level. While you have the hood open, check all drive belts, such as the fan belt. See if they are frayed or cracked. If a belt looks too loose or tight, check its tension. Depress the belt between two pulleys with your thumb. It should deflect from 1/2 inch to 1 inch with reasonable pressure.

Check to see if the battery is clean and free of corrosion. The cables should be tight. If they look loose, move the cable connections to see if they are tight. Tighten loose connections with the proper size wrench, turning the nut clockwise.

Also, during starting, note if the battery spins the engine freely and without hesitation. If the starter is sluggish, the battery should be written up on the Operator's Inspection Guide and Trouble Report to be checked for its condition.

Check to see if the horn operates. Turn on and check all the lights to see if they operate. If anyone else is around, have him or her see if the stoplights are working when the service brakes are applied. On some vehicles, you can check the stoplight bulbs by checking operation of the directional signals. Also, look for broken light lenses and for broken or missing reflectors.

Check the vehicle's instruments before and after starting the engine. For example, the ammeter should show zero with the ignition switch off and quite likely a discharge with the switch on. It should register a charge after the engine is operating. Be sure that all instrument readings are normal. If not, write them up to be checked. Also, you can check the fuel supply at this time.

Examine the wiper blades to see if they are cracked or if pieces of rubber are missing. After the engine is running, turn the wipers on to be sure they operate properly. (NOTE: Do not check the wipers for operation if a blade is missing. You may scratch the glass with the wiper arm.)

If the windshield is dirty, clean it. Normally, you clean your windshield when you clean your vehicle. Check for windshield breakage that would interfere with your vision. On a cracked windshield, be sure that there are no edges on which you can cut yourself or that no pieces are apt to fall out and injure somone.

You should inspect the seat belts to be sure they are anchored and not excessively frayed. If the vehicle is equipped with a fire extinguisher, see that it is in place. If it has a visual indicator, see if the extinguisher has been used. Also, check the rear mirrors and adjust them so that you can use them easily.

Before you move the vehicle, make some checks on the steering and brakes. Turn the steering wheel to be sure that the linkage is attached and that there is not an excessive amount of free travel. Step on the brake pedal to see if the brakes are working properly, and apply the parking brake to check its operation.

One more point which should be mentioned here:

Open the drain cocks on the air tanks of an air brake system to discharge any condensation after each use. If this water isn't drained, it could cause corrosion or rust inside the system. If the corrosion or rust flakes off, particles could be forced through the lines, causing failure or poor operation of parts of the brake system. Also, this water may freeze in the tank of lines. After draining the water from the tank, be sure that you close the petcock immediately; don't wait until the next time you operate the vehicle.

In most cases, you are not responsible for knowing when the vehicle's lubrication and oil changes are needed. However, if there is a lubrication and service guide on the windshield, you must check this form to see when the services listed are due. You are responsible for letting your supervisor know whenever any of the listed services come due.

You also are responsible for carefully noting how your vehicle operates. Enter any malfunction or indication of improper operation on the Operator's Inspection Guide and Trouble Report. If the deficiency affects the safety of the vehicle or if further operation might cause additional damage, you should report to the maintenance shop immediately. Otherwise, you can have the deficiency corrected at a more convenient time.

1. Why do you make a preoperational inspection on a vehicle?

2. You have been driving the same pickup for several days. During your preoperational check, you discover a bent fender. What should you do?

3. During your preoperational check, you find that a tire is about half flat. What must you do?

4. What do you do when you discover a fan belt with cracks in it?

5. When you are inspecting the battery in your vehicle, what are you checking for?

6. During your operational check on a vehicle, you find one wiper blade and one arm missing. What do you do about checking the wipers for operation?

7. What safety equipment would you check?

8. How can you be reasonably sure that the service brakes are all right before you move a pickup?

9. What should you do if you are driving a pickup on base and you notice a grinding noise that seems to come from one of the rear wheels?

817. Explain how a vehicle operator services a vehicle.

Servicing. Servicing is checking for necessary replenishment of gasoline, oil in the crankcase, water or antifreeze in the cooling system, and air in the tire.

Fuel. Fuel tanks should be kept as nearly full as possible. This is especially important during cold weather to prevent condensation of moisture inside the tank. Moisture not only contaminates the fuel but may freeze within the fuel lines. Gas tanks should not be filled to the top of the filler pipe. This allows for expansion of gasoline during hot weather.

Take the following precautions during vehicle fueling to prevent the possibility of fire or explosion.

a. Do not fuel vehicles near open flame or spark-producing devices.

b. Do not fuel vehicles indoors.

c. Do not smoke or permit others to smoke.

d. Turn the vehicle ignition (and all other ignitions) off.

e. Make sure that the nozzle of the fuel hose is in constant contact with the intake pipe of the vehicle's fuel tank. This eliminates sparks from static electricity.

f. Allow spilled fuel to evaporate before starting the engine.

g. Whenever large amounts of fuel are spilled, notify the fire department immediately to remove the hazard. (While awaiting the arrival of the fire department, stand by the spill with suitable firefighting equipment.)

h. Where fuel filler pipes are located close to the engine manifold or other source of ignition, allow the engine to cool before fueling the vehicle.

Oil and automatic transmission fluid. Check the engine oil or automatic transmission fluid frequently with the "dipstick." You cannot rely on the oil pressure gage to show the amount of oil in the crankcase; it shows pressure only. Make sure that the transmission is in the proper position when you are checking the transmission fluid level. The correct position for this check usually is shown on the dipstick. If not, consult the vehicle manual or your supervisor.

If you must add engine oil or transmission fluid, take every precaution to prevent dust or other foreign matter from entering the crankcase or transmission case. Clean the measuring can, the funnel or pouring spout, and the filler pipes with a clean cloth. Add only the proper amount of oil or fluid. Overfilling can cause damage. Use the proper grade of oil or fluid for the season. When you finish, wipe off any spilled oil or fluid.

Water. Keep the water in the radiator at the proper level below the overflow pipe. An overheated engine should be allowed to cool before water is added to the radiator to prevent damage to the engine. If you must add water to an overheated engine, let the engine run and add water very slowly.

In freezing temperatures, antifreeze should be added. If no antifreeze is available, care must be exercised to prevent freezing. You must drain the cooling system if the vehicle is to sit very long without the engine operating. When the cooling system must be drained, it is necessary on most engines to drain the cylinder block as well as the radiator.

Use clean water to fill the cooling system. If conditions require you to use dirty water, the cooling system should be drained and refilled with clean water and a rust inhibitor at the earliest opportunity.

Exercises (817):

1. Why should fuel tanks be kept as nearly full as possible during cold weather?

2. When you are fueling a vehicle, what should you do to eliminate sparks from static electricity?

3. What is used to check the amount of oil in the crankcase?

4. How should you add water to an overheated engine?

818. Explain how a vehicle should be cleaned.

Cleaning. As we previously mentioned, the cleaning of a vehicle is a driver's function. Just cleaning the exterior of the vehicle isn't enough. The engine and accessories, interior, undercarriage, and any auxiliary equipment must be cleaned as well.

Engine. If a cleaning agent is needed to clean an engine, use only Air Force-approved solvents. Gasoline and other highly flammable liquids must never be used as cleaning agents. Before applying the solvent, get a small piece of wood or putty knife and scrape away any caked grease or dust. Once the engine is clean, it takes only a few minutes each day to keep it clean. After you finish driving the vehicle each day, take a rag and wipe the dust and oil from the engine and its subassemblies.

Occasionally, radiator cores become plugged with bugs, leaves, brush, and other similar debris. If this happens, do not attempt to clean the core by using a stick or other sharp instrument. The radiator core is soft and is easily damaged. You can wash the foreign material out by flushing it with a water hose from the engine side of the radiator. Be sure the water pressure isn't great enough to damage the core. If you can't get the material out with water, use compressed air.

When you are using compressed air, there are a few safety precautions to observe. Serious injuries have been caused by the improper use of compressed air. Don't blow dirt or dust from your clothes, it is strong enough to reach the body. It has been estimated that an internal pressure of only 4 pounds per square inch can rupture the intestine. Never direct compressed air at anyone. Never use compressed air to clean dirt or debris from a work area. An eye can very easily be injured or put out by flying debris.

Interior. The inside of your vehicle must be kept clean at all times. Remove all trash, books, bottles, oily rags, and other similar objects from under and behind the seats. A vacuum cleaner is ideal for cleaning the seats, upholstery, and carpets. Brush out the cab with a whiskbroom and then wash it with a sponge and water. A sponge and water also are good for cleaning leather, leatherette, dash, armrests, and window strips. Use a chamois to clean windows. Never turn a water hose inside a vehicle. This soaks the mats and rusts the floorboards. Sweep and dry mop the floors of buses. Sweep the beds of trucks and trailers.

Exterior. Normally, all you need to wash the exterior of your vehicle is a pressure hose, rags, and a GI brush. When washing a vehicle, wet it first to avoid scratching the paint, then use a rag and start from the top and work down. Then you wet the wheels and use the brush to break loose any caked mud or dust. After this is done, rinse thoroughly. After the washing operation is complete, chamois the vehicle dry. Polish the vehicle when needed. Be sure the vehicle is clean, and use clean rags. Never polish a vehicle in the sun.

Undercarriage. Normally, the pressure hose is sufficient for cleaning the undercarriage, though unusual conditions may necessitate the use of steam. When either is used for this cleaning, spray grease seals and fittings as little as possible. (NOTE: Steam is dangerous and must be handled with care. Consult your supervisor when steam cleaning is necessary.)

Auxiliary and special equipment. Normally, auxiliary and special equipment, such as motors, generators, compressors, etc., can be kept clean with just a rag. Go over the equipment frequently, wiping off any dust and oil that have collected.

Exercises (818):

1. What cleaning agents are used to clean a vehicle?

2. How should you clean bugs and trash from the radiator core?

3. Why should you never turn a water hose on inside a vehicle?

4. How should the floor of a bus be cleaned?

5. What should you use to clean the undercarriage?

6. Once auxiliary or special equipment is clean, how should you keep it clean?

4-3. Two-way Radio Operation

As an AGE dispatch driver, you will be required to operate two-way radios, maintain radio discipline, make identification broadcasts, report radio failure, and use recommended code systems when transmitting. Most vehicles assigned to dispatch service are equipped with two-way radios. Therefore, all drivers should be trained to use this equipment.

819. Explain procedures for operating two-way radios.

Two-way Radio Operation. The operation of the radio equipment itself is almost foolproof. Operation of the central transmitter-receiver and the radios in the vehicles are essentially the same. Each radio is equipped with a STBY-ON-OFF switch channel selector, squelch control, volume control, and microphone button. These controls are all shown in Figure 4-6. Some radios have a transmit-receive switch mounted on the front panel instead of a microphone button.

To operate the radio, turn the set on by turning the STBY-ON-OFF switch to either the ON or STBY position. Turn the switch ON if you are expecting to be called; turn it to STBY if you do not expect a call. The green signal light (one of the two lights found at the bottom center of the radio) glows only when the switch is on. This tells you at a glance whether the switch is in the ON or STBY position. STBY uses the least amount of battery power, since only the receiver is on when the switch is locked in this position.

The channel selector is not used on radios installed in taxi vehicles. You have only one frequency available, thereby eliminating the need for changing channels. The squelch control is a noise eliminator. This control is adjusted in conjunction with the volume. Turn the squelch control to the right as far as it will go until a hissing sound is easily heard but is not annoyingly loud. Then turn the squelch control to the left until the hissing sound stops.

Transmissions are quite simple. Turn the STBY-ON-OFF switch to ON, pick up the microphone, and if no one else is talking, press the microphone button (or move the transmit-receive switch to TRANSMIT) and send your message. When the microphone button is pressed, the red transmit light (the second of the two lights at the bottom center of the radio) will come on. Upon completion of your message, release the mike button (or move the transmit-receive switch to RECEIVE) immediately, since you cannot receive while the button is pressed. Transmissions should be made in a moderate tone of voice. Loud speech causes the words to become garbled and lose their clarity. On the other hand, too soft a speech is hard to hear, requiring high volume on the receiver. Excessive volume increases hum, static, and other interfering noises.

Care should be taken to pronounce all words clearly and distinctly. Persons who tend to be rapid speakers should slow their rate of speaking to increase understandability, use short, everyday words to reduce the possibility of messages being misunderstood. An additional precaution—all persons must carefully avoid the use of profanity. Use of profanity on the air is absolutely forbidden by the Federal Communications Commission. Even if this were not so, its use would be in poor taste and would indicate a lack of good judgment.

Most taxi radio systems are set up so that they transmit and receive on the same frequency. This arrangement makes it possible for you to talk to other taxi drivers. However, the use of radio communications for other than official business is prohibited. Unofficial use of transmitters is cause for disciplinary action. If it should become necessary for you to communicate with another taxi driver, you must do so only after receiving permission from the taxi dispatcher.

If your radio equipment becomes inoperative, report it to the dispatcher so that corrective action may be taken.

Identification Codes. For identification purposes, the central transmitting station will have a designated code name. Each radio taxi vehicle also has a call number assigned. Block and individual numbering of vehicles is used by most bases; e.g., numbers 1–10 for sedans, 11–20 for station wagons, and 21–35 for pickups. All communications between the central transmitting station and the taxi vehicles must be made only after using the designated call numbers for identification.

Transmitting Codes. It generally is accepted practice to use a code system with radio taxi service. The purpose of the code system is to reduce the transmission time of messages without detracting from their clarity. There are two reasons for keeping the airwaves free of unnecessary chatter or long, detailed informational messages. First, when a driver is carrying on a long-winded conversation with the dispatcher, it is impossible for other drivers to contact the dispatcher for their assignments or needed information. Second, at many installations, some other activity may be assigned the same radio frequency as that used by the base taxi service. You must consider the needs of the other activity, too.

Figure 4-6. Two-way radio.

The preceding requirements have resulted in the development of code numbers with specific meanings. These codes are established by some major commands. Bases of commands not having a specified code system have developed their own.

The system may consist of a few code numbers covering only the most common transmissions made between you and the dispatcher. However, some places use a complete code system that covers practically all possible transmissions that may come up in taxi operation.

The following code system is typical of those employed for frequently used transmissions. All numbers above nine are pronounced as a whole number; i.e., 10 is pronounced "ten," not "one zero." These codes are only examples, and are not to be used unless approved by your organization.

10-1 Receiving poorly.
10-2 Loud and clear.
10-3 Standby.
10-4 Acknowledge.
10-5 Relay message.
10-6 Busy.
10-7 Out of service.
10-8 In service.
10-9 Repeat message.
10-11 Dispatching too fast.
10-12 Officials or visitors present.
10-13 Advise weather and road condition.
10-14 Return to station.
10-18 Complete present assignment as quickly as possible.
10-19 Request relief.
10-20 What is your location.
10-21 Require maintenance.
10-36 Correct time.
10-97 Arrived at scene.
10-98 Finished with last assignment.

Exercises (819):

1. Explain how you would operate the two-way radio to transmit.

2. Describe how the squelch control should be adjusted.

3. Why should you release the microphone button immediately after completing a transmission?

4. If the dispatcher has trouble understanding your words on the receiver, and if the volume of the receiver is high enough and you are speaking slowly and clearly, what is probably the trouble?

5. You are driving a radio-controlled taxi vehicle and need to talk to another taxi driver. Under what conditions are you permitted to to talk to him or her?

6. When using two-way radios, conversations between the dispatchers and drivers should be as brief as possible. What means is used to reduce the transmission time?

4-4. Towing Safety Precautions

Each towing vehicle presents a hazard to operating personnel and property.

Improper or unsafe use of equipment accounts for many towing vehicle accidents. Defective and damaged equipment is a potential source of accidents. Gasoline-powered vehicles often present a fire hazard to buildings and aircraft.

820. Explain towing safety precautions for operating towing vehicles.

Precautions. To help insure the safety of personnel and to help prevent damage to equipment, materials, and property, you must observe the following towing safety precautions when operating towing vehicles:

a. Operation of towing vehicles must be limited to qualified operators.

b. Towing vehicle must not be fueled in buildings or in other areas where flammable vapors may be present or where hazardous materials are stored. Fueling must be done in a designated outside area, at least 20 feet from a building.

c. Vehicles with internal combustion engines must be equipped with flame and spark arrestors on their exhausts and carburetors whenever they are operated in buildings or in other areas where a fire hazard exists.

d. Materials handling equipment must not be shifted from forward to reverse, or vice versa, without coming to a complete stop. This prevents damage to the vehicle. It also lessens the possibility of losing the load caused by a sudden change in direction.

e. You must make certain that you have sufficient clearance (overhead and sides) through doorways, at loading docks, in aisles, and where turns are made.

f. You must give your full attention to operating the equipment. Therefore, you are not permitted to eat, drink, or smoke while driving, nor to engage in unnecessary conversation.

g. You are responsible for safe delivery of loads. If you believe a load cannot be moved safely, have the condition corrected before moving the equipment.

h. Towing vehicles parked inside buildings must be parked only in areas approved by the fire department. No vehicle should be parked in front of fire alarm boxes, fire extinguishers; or safety equipment, in aisles, or other areas where it would become a safety hazard.

i. When equipment is parked inside a building, drip pans must be placed under vehicles parked for long periods. On equipment with the gas tank mounted higher than the carburetor, fuel should be turned off at the tank.

j. Towing connections and hoisting mechanisms must be inspected before each period of use. Unsafe equipment must be taken out of service until repairs are made.

k. Do not exceed a speed of 5 miles per hour in buildings or other work areas.

l. Gasoline- and diesel-powered equipment must not be "warmed up" inside buildings. This reduces the possibility that carbon monoxide will accumulate in buildings.

m. You must not attempt to repair or adjust any mechanical part of materials handling equipment. However, report defects to your supervisor or personnel who are authorized to correct the deficiencies.

n. Gasoline- or diesel-powered equipment must not be used in buildings that are not properly ventilated.

o. To warn others, stop and blow the horn before going through doorways, around blind corners, and through aisle intersections.

Flight line. The following practices must be observed at all times on the flight line. Careful attention and strict adherence to these precautions will prevent accidental damage to aircraft and possible injury to both flight and ground personnel.

Parked aircraft. Vehicles must not pass under any part of an aircraft unless absolutely necessary. If it is absolutely necessary, make a visual check to be sure there is sufficient clearance. Never back your vehicle in the immediate direction of any aircraft except as authorized in certain towing, loading, unloading, or fueling operations. If you must do so, post a guide and install bumper checks to keep you from backing into the aircraft.

CAUTION: You must approach parked aircraft with the driver's side of the vehicle toward the aircraft. Do not drive or park closer than 25 feet from an aircraft. When your mission and the type of vehicle require you to come closer than 25 feet, use a guide to insure maximum safety.

Taxiing aircraft. Under no circumstances may you stop in front of, or drive into the path of, taxiing aircraft. You must never drive your vehicle between an aircraft and its follow-me guide.

Aircraft engine runup. For maximum personnel safety, no vehicle should stand, park, or be driven closer than 25 feet in front of any aircraft when its engines are operational or about to be operated. Local policies may require even greater distances.

Vehicle lights. You must turn off your headlights at night when they are directed toward a moving aircraft. This keeps you from blinding the pilot or affecting his or her night vision. You must leave your parking lights on so that the pilot knows your position. As soon as the aircraft is out of range of the lights, turn the headlights back on.

Foreign object damage (FOD) prevention. Vehicles operating on the flight lines are a major source of foreign objects which damage aircraft. A vehicle tire picks up nails, gravel, rocks, and other similar foreign objects. These may be lost while the vehicle is operated on the flightline. Also, objects may be lost from vehicles. Any of these foreign objects may be sucked into jet engines with disastrous results. Such objects also can damage aircraft tires. Before operating on the flightline, insure that all equipment in or on the vehicle is properly stowed and secured. You also must inspect vehicle tires and remove any foreign objects. Be sure to remove any rocks or other objects from between dual tires.

Speed limits. Except in unusual cases, vehicles must not go faster than 10 miles per hour on the flightline. No vehicle may exceed 5 miles per hour when it is near aircraft, and aircraft must never be towed at more than 5 miles per hour.

Wheeled equipment. Compressors, auxiliary power units, and similar equipment will be towed by tugs or other vehicles with suitable trailer hitches. In no event will equipment be towed faster than 15 miles per hour. Safety chains will not be required on aerospace ground power equipment except weapons trailers, which are designed to be towed or will be towed at 15 miles per hour or less.

Driver's seat vacated. Ignition will be turned off, brakes set, and gear lever placed in reverse or in park when the driver's seat is vacated.

Crossing taxiways. You must come to a complete stop before entering or crossing a taxiway. Before proceeding, you must determine visually that the way is clear.

Crossing runways. You particularly must be cautious when you have to drive across runways. Come to a complete stop at least 100 feet from the runway and wait for clearance (a light signal or radio contact) signal from the control tower.

Control tower signals. Tower personnel have control of all flightline vehicles. You must observe and obey their signals and radio instructions. The meaning of the control tower signals must be posted in plain view on either the dash panel or other appropriate place on your vehicle.

The light signals flashed from the control tower are:

Steady green light—Clear to cross.
Steady red light—STOP. Do not move your vehicle.
Flashing red light—Clear active runway immediately.
Flashing white light—Return to starting point.
Red and green light—General warning. Exercise extreme caution.

Exercises (820):

1. When you are operating towing vehicles inside a building, where should you have them fueled?

2. What is the Air Force policy concerning smoking while operating a towing vehicle?

3. What must you do when you have to drive under part of an aircraft?

4. What is the rule for backing a vehicle on the flightline?

5. How far from a runway must you stop to await clearance to cross?

6. When you are operating on the flightline at night, when must you turn your headlights off?

7. How do your receive clearance to cross a runway?

8. What must you do when the control tower gives you a flashing red light?

9. What does a steady red light from the control tower mean?

10. What does a flashing white light from the control tower mean?

Answers for Exercises

CHAPTER 1

Reference:

800 – 1. Basically the prime mover, MJ–1A is gasoline driven, whereas, MJ–1B is diesel driven.
800 – 2. The rotary by-pass valve selects drive or tow position.
800 – 3. The directional control lever.
800 – 4. Throttle control, by changing the engine speed and the accelerator pedal, by changing the stroke of the piston.
800 – 5. Piston pump.
800 – 6. Pressure relief valves, located in the pump discharge section.
800 – 7. Prevents collapsing of the cantilever lifting arms in the event of hydraulic pressure failure.

801 – 1. Check valve and air bleed valve.
801 – 2. Piston pump.
801 – 3. Counterbalance manifold.
801 – 4. Hydrostatic.
801 – 5. Prevents pressurized fluid from returning to the piston pump.

802 – 1. Review maintenance forms.
802 – 2. Periodic.
802 – 3. The unit workcard will always take precedence.

803 – 1. Loose or corroded connections.
803 – 2. Ammeter.
803 – 3. Flywheel alternator system.
803 – 4. The overcenter values out of adjustment.
803 – 5. Engine operating speed is too slow, or because of a hydraulic leak.

CHAPTER 2

804 – 1. Wet-type liners are used on engines having water jackets that extend into the cylinder bore. Dry-type liners are used on engines having a closed cylinder water jacket.
804 – 2. Short skirt pistons could cause more piston shake.
804 – 3. For better heat dissipation the piston heads are made thicker.
804 – 4. Standard size.

805 – 1. On gasoline engines the springs are attached to the valve stems by locks or keepers but on some large diesel engines use nuts screwed onto the valve stem to hold the spring retainer in place.
805 – 2. Insures that when fuel is injected it is thoroughly mixed with the air at the time combustion takes place.

806 – 1. The supercharger is usually driven by the engine while a tubocharger utilizes the flow of exhaust gases to increase the amount of air taken into an engine.
806 – 2. Forces a large quantity of low-pressure air into the cylinders and increases the scavenging efficiency of the engine.
806 – 3. Due to the increase of turbulence a better mixture of fuel and air results.
806 – 4. The position is maintained by the spur gears or timing gears which drive the second impeller.
806 – 5. The intake valve is advanced and the exhaust valve is retarded.
806 – 6. An increase in turbulence created by the supercharger causes the fuel and air to mix more readily, thereby decreasing fuel consumption.
806 – 7. Balance. Excessive vibration at high rpm will result from an unbalanced condition.

807 – 1. Relief valve.
807 – 2. Tank, shutoff valve, primary filter, transfer pump, secondary filter, fuel manifold, ejector pump.

808 – 1. (1) c.
(2) b.
(3) a.
(4) b.
(5) a.
(6) c.

808 – 2. Fuel flow is proportional to fuel pressure, flow time and the size of the fuel passage.
808 – 3. The injector delivers fuel into the combustion chamber at the right time.
808 – 4. By shutting off fuel to the injectors.
808 – 5. The gear pump.
808 – 6. By opening and closing idle and throttling passages, depending on engine requirements.
808 – 7. Fuel pump pressure.
808 – 8. Because the rate of fuel flow through the system is constant at a given rmp.
808 – 9. Primary, secondary, injector inlet, injector outlet.
808 – 10. Inject, atomize, pressurize, and meter fuel.
808 – 11. A spring-loaded relief valve is placed in the system to return excess fuel to the pump inlet.
808 – 12. The constant flow of fuel aids in cooling and eliminates air pockets.
808 – 13. By rotating the plunger through use of the control rack the amount of fuel delivered to each cylinder can be limited to control engine speed.
808 – 14. Retards or advances the closing of ports and the beginning and ending of the injection period.

809 – 1. Cause abrasion of the injection plates resulting in error of watered fuel.
809 – 2. It keeps the injection equipment operating efficiently and cost effectively.

810 – 1. Use one of the fuel pipes removed from the injector as a jumper between the fuel inlet and return manifold.
810 – 2. Shut off the fuel supply to each cylinder, in turn, and listen for a difference in engine operation.

CHAPTER 3

811 – 1. Engine generator control switch.
811 – 2. Engine stop control T-handle.
811 – 3. Located in the upper center of the engine control panel which supplies power to the rectifier, closing the load contactor.
811 – 4. When the 24-V power supply switch is in the UP position.
811 – 5. In the generator control tray.
811 – 6. Five.
811 – 7. 375 to 385.

812 – 1. Provides 12-V potential for operations of the electrical system.
812 – 2. Two 6-V batteries connected in series.
812 – 3. Energizes the starter motor.
812 – 4. Auxiliary starter solenoid (L10).
812 – 5. Provide lighting for night operations of the unit.
812 – 6. Engine control panel and generator control box.
812 – 7. Three-position toggle switch.
812 – 8. Spring-loaded in the BUILD UP position.
812 – 9. Provides power to the electronic governor control box allowing the engine to operate at normal governed speed.
812 – 10. When the engine is operating, after the oil pressure closes.

813 – 1. Provides power to the contacts of the AC load contactor relay K1.
813 – 2. Current transformers lower the output load current to a lesser value.
813 – 3. Automatic position.
813 – 4. Sense generator's output for an overload condition.
813 – 5. Overload, overvoltage, undervoltage, overfrequency or underfrequency.
813 – 6. First, the underfrequency relay contacts will close, energizing the underfrequency auxiliary relay K23, gating the appropriate SCR, and turning on the underfrequency fault indicator. The K1 contactor will deenergized.

814 – 1. Analysis.
814 – 2. The best method is to time the circuit in question back to the first place where you know for a fact that there was power.
814 – 3. Analysis.
814 – 4. Load contactor fuse F1.

CHAPTER 4

815 – 1. Vehicle operations, ground safety, and Security Police.
815 – 2. DD Form 1360.
815 – 3. To provide information on a driver's official qualifications, background and experience, examination findings, and performance record. It also provides for recording awards, traffic violations, and accidents.
815 – 4. It is forwarded to your new base.
815 – 5. His or her permit may be suspended or revoked.
815 – 6. SF 46.
815 – 7. An indefinite period.
815 – 8. You retain your permit.
815 – 9. AF Form 1252.
815 – 10. Vehicle servicing and minor maintenance.
815 – 11. One month.
815 – 12. Daily.

816 – 1. To be sure the vehicle is safe and ready to depart.
816 – 2. Record the damage on the Operator's Inspection Guide and Trouble Report and also report it to your supervisor.
816 – 3. Change the tire.
816 – 4. Record it on the Operator's Inspection Guide and Trouble Report so that it can be replaced.
816 – 5. Cleanliness, corrosion, and loose cables.
816 – 6. Go ahead and check for operation.
816 – 7. Seat belts, fire extinguisher, and rear-view mirrors.
816 – 8. Step on the brake pedal to check the brakes' operation.
816 – 9. Enter the discrepancy on the Operator's Inspection Guide and Trouble Report and report to the maintenance shop immediately.

817 – 1. To prevent condensation of moisture inside the tank.
817 – 2. Keep the fuel nozzle in contact with the vehicle.
817 – 3. A dipstick.
817 – 4. Allow the engine to run and add the water very slowly.

818 – 1. AF-approved solvents.
818 – 2. Wash them out from the engine side with a water hose. If this fails, blow the plugging material out with compressed air.
818 – 3. The mats become water soaked and the water will rust the floorboards.
818 – 4. By sweeping and dry mopping.
818 – 5. The pressure hose or, for unusual conditions, steam.
818 – 6. Go over the equipment with a rag after you finish with the equipment.

819 – 1. Turn the set on and adjust all of the controls. Then press the mike button (or move the transmit-receive switch to TRANSMIT) and begin your transmission, speaking into the mike.
819 – 2. Turn the squelch control to the right as far as it will go and adjust the volume control until a hissing sound is easily heard but is not annoyingly loud. Then turn the squelch control to the left until the hissing sound stops.
819 – 3. Holding the button down prevents incoming messages.
819 – 4. You are probably speaking too loudly into the microphone.
819 – 5. For official business and then only after the dispatcher gives you permission to do so.
819 – 6. A code identification system for identifying vehicle and the central transmitter-receiver, and a series of code numbers to be used when transmitting messages.

820 – 1. In a designated outside area, at least 20 feet from a building.
820 – 2. No smoking is permitted.
820 – 3. Stop and make a visual check to be certain that there is sufficient clearance before proceeding.
820 – 4. Do not back your vehicle in the direction of nearby aircraft except as authorized in loading, unloading, and fueling operations. In these cases you must post a guide.
820 – 5. At least 100 feet.
820 – 6. When they are directed toward a moving aircraft.
820 – 7. You will receive a steady green light from the control tower.
820 – 8. Clear the active runway.
820 – 9. Stop and do not move your vehicle until you receive another signal from the control tower.
820 – 10. Return to starting point.